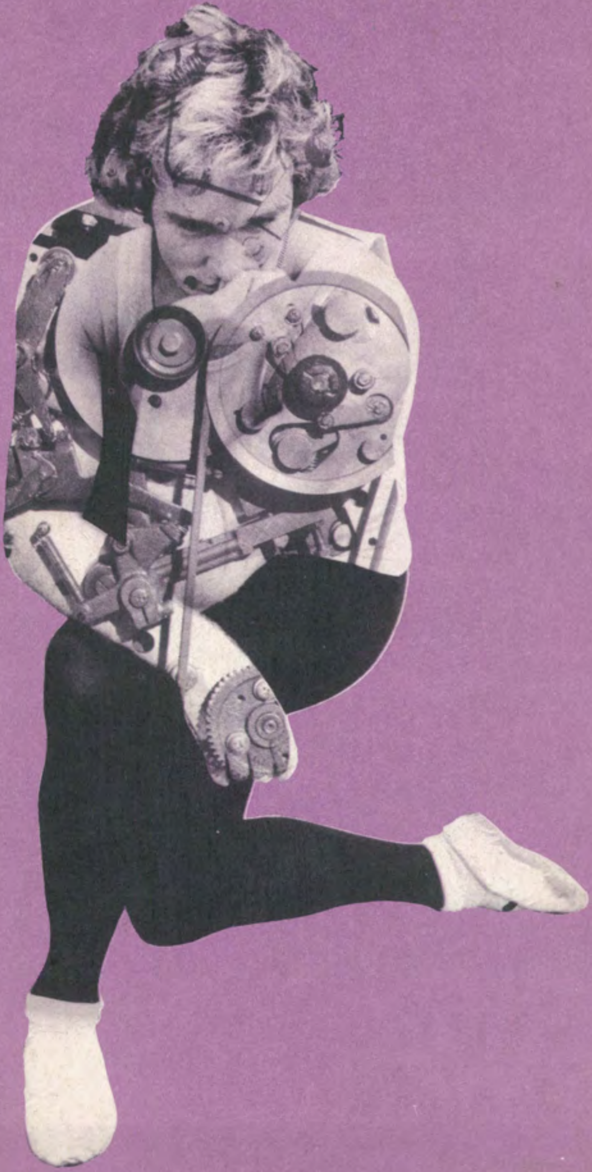
27

The Human Machine

asep



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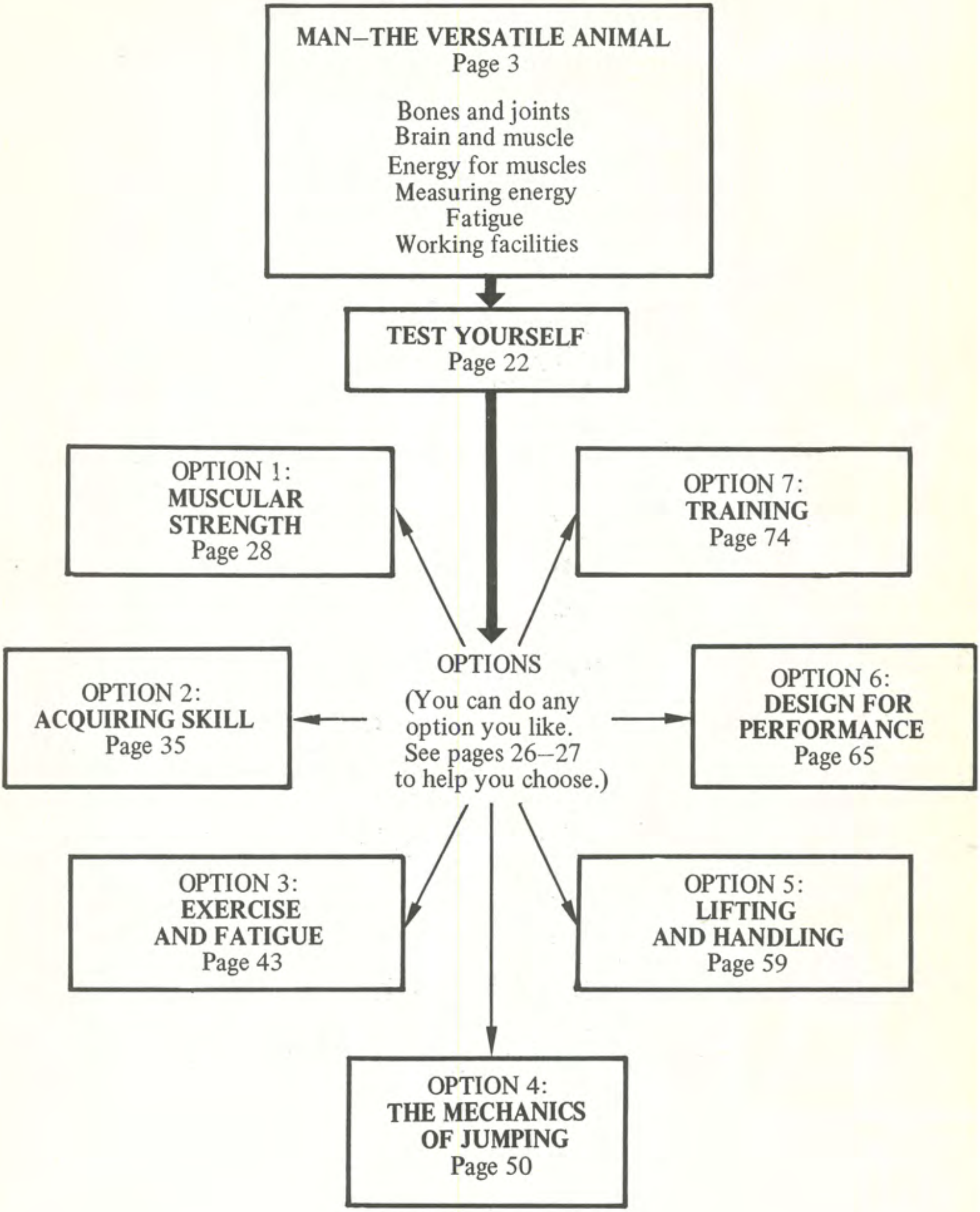

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Photo by courtesy of The Age, *Melbourne.)*

Man—the Versatile Animal

The human body is a marvellous machine. It is more complex than any computer or car. Movements of the body can be beautiful and many tasks are performed with precision.

Much about man can be studied, including his personality, his relationships with other people and his physical performance.

In *The Human Machine* you can find out many things about physical performance and some features of your working environment.

BUSBY HIGH SCHOOL

DATE	NAME	CLASS

ACTIVITY 1: MOVEMENTS OF THE BODY

Man is a versatile animal. He can perform many different activities on land and in water. He has made machines which allow him to move through the air and into space.

His movements often involve some parts of the body more than others.

His movements sometimes involve his whole body.

(Photo by courtesy of The Age, *Melbourne.)*

Stand up and move forward a few paces. Don't turn round. Return to your seat. In which directions have you moved? Up? Down? Forward? Any others? Are there other directions in which the whole body might move, as in a difficult dive or on a trampoline?

✍ 1 There is a space on page 3 of your record book to list the directions in which your whole body may move.

Whenever you see the sign ✍ followed by a number it means that there is something to do in your record book.

OK. Now let's see you do it with your nose!

Move your right arm behind your head and grasp the lobe of your left ear. The chimpanzee is probably the only other animal which can do this.

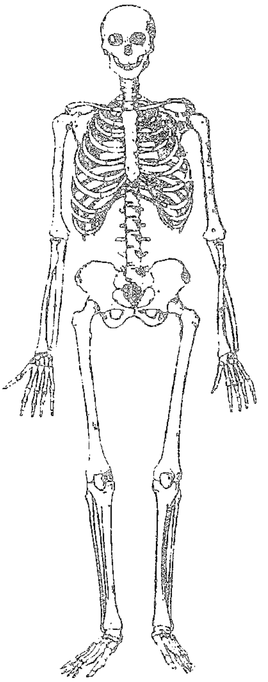
Your hands can perform a great variety of precise movements. In the photo below you can see how precise a watch-maker must be with his finger movements.

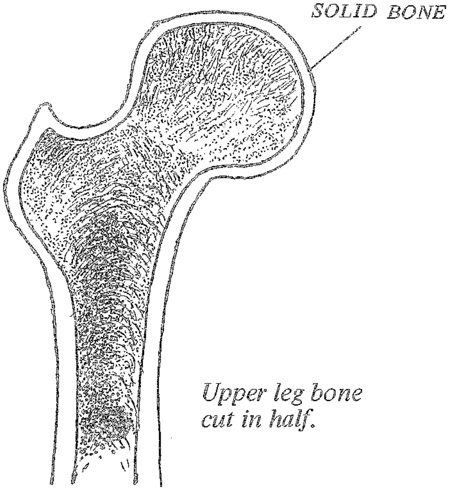
No machine can mimic all the delicate actions that your hand can perform. Artificial limbs can imitate only a few of the complex movements of human limbs.

Bones, joints and muscles are involved in all your movements. Movements of the arms and hands can be particularly delicate and precise.

BONES AND JOINTS

Your skeleton is a framework of bones. The long bones are hollow like the pipes used for scaffolding. They are light but strong.

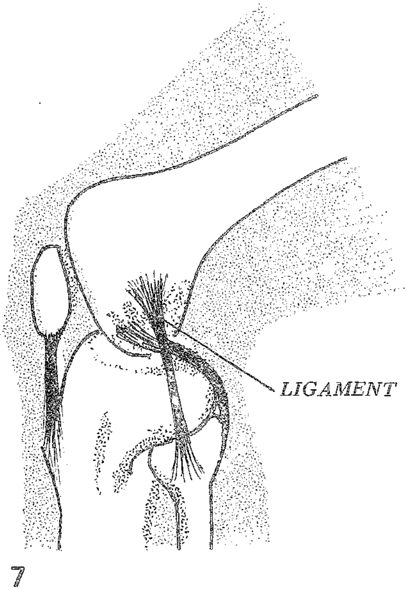




Upper leg bone cut in half.

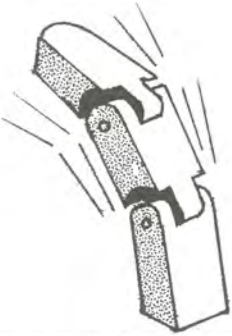
The bones are held together at joints by ligaments, as shown below.

The joints permit bending and allow your body parts to move. The joints are lubricated by a liquid.

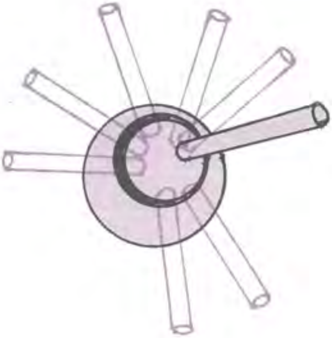


ACTIVITY 2: TYPES OF JOINTS

The range of movement possible for the hand and arm is determined by the type of joint. Grasp your index finger above the knuckle and hold it firmly. Now look at the directions in which the top of the index finger can be moved. The finger joints are like door hinges. They allow movement in one direction only.



The arm is attached at the shoulder by a **ball and socket joint**. This allows movement in a number of different directions. Many adjustable ar-vision mirrors in cars have such a joint.



2 Find the following joints and observe the sorts of movement which can be made by them. Use the table in your record book to group them as either hinge joints or ball and socket joints:

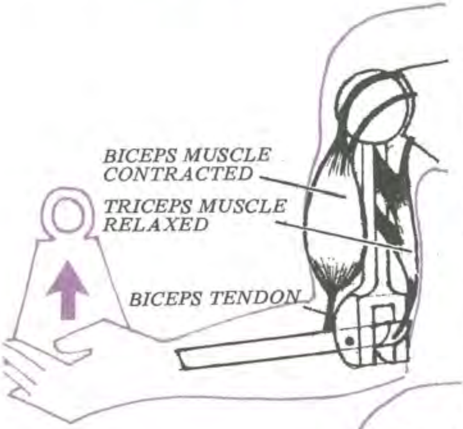
☐ shoulder ☐ elbow ☐ toes ☐ hip ☐ knee ☐ knuckles.

ACTIVITY 3: TENDONS AND MUSCLES

Bones and joints permit a range of movements but it is the muscles that cause bones to move.

The muscles in the forearm move the hand. Feel and observe how these muscles operate. Open and close your hand, rotate your wrist.

Muscles are attached to bones by **tendons.** Try to find your own Achilles tendon. This tendon attaches your calf muscle to the bone in your heel, permitting the bending movement of the foot.

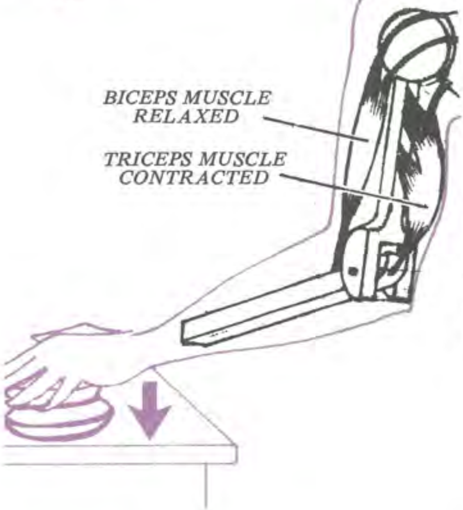


Muscles operate in pairs to bring about movement of the bones to which they are attached. As one muscle of a pair contracts (shortens), the other relaxes.

Bend your elbow and feel the **biceps tendon** in your upper arm. The **biceps muscle** is at the front of the upper arm and the **triceps muscle** is at the back.

Bend your arm and feel which muscle contracts. You can cause this muscle to contract tightly by clenching your fist and using your forearm muscles.

Straighten your arm and use your forearm muscles to make your arm rigid. The muscle involved in straightening the arm is now tightly contracted. Muscles can never push—bones are moved by muscles pulling as they contract.



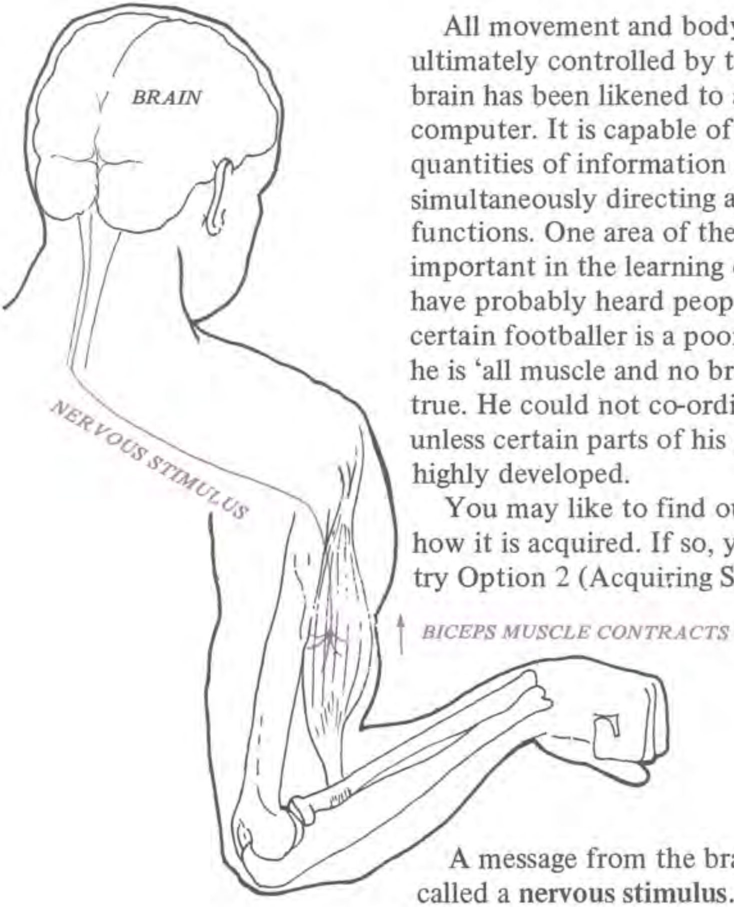
3 Which muscle contracts as the arm is bent?

4 Which muscle contracts as the arm is straightened?

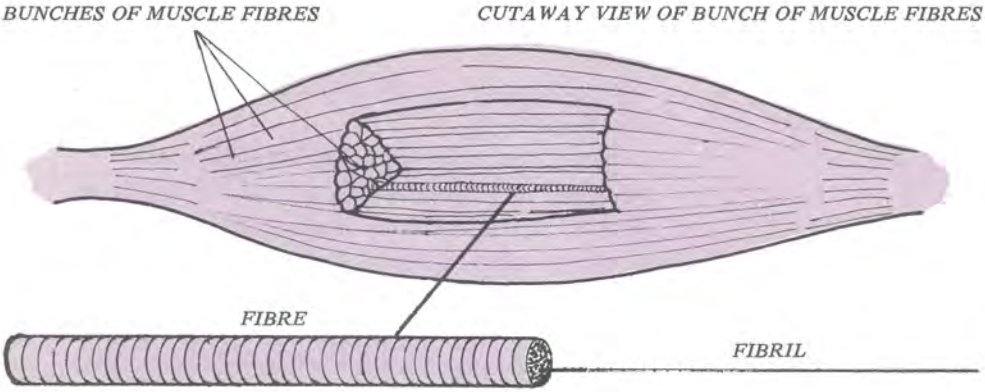
BRAIN AND MUSCLE

All movement and body functions are ultimately controlled by the brain. The brain has been likened to a highly organized computer. It is capable of storing vast quantities of information and simultaneously directing a wide variety of functions. One area of the brain is important in the learning of skills. You have probably heard people say that a certain footballer is a poor player because he is 'all muscle and no brain'. This is not true. He could not co-ordinate his actions unless certain parts of his brain were highly developed.

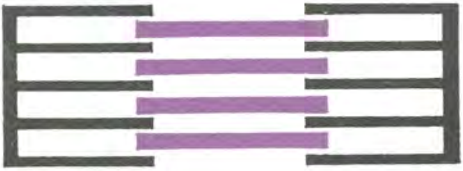
You may like to find out about skill and how it is acquired. If so, you could later try Option 2 (Acquiring Skill).

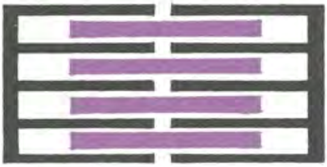


A message from the brain to a muscle is called a **nervous stimulus**. Muscles contract and relax at different times because they have been **stimulated** at different times. Imagine what would happen if the brain sent the wrong messages and both the biceps and triceps muscles contracted at the same time. This does occur in certain diseases (e.g. lockjaw) and the body becomes strained and rigid. The muscles all try to pull against one another. An electric shock also causes muscles to do this because it stimulates all the muscles at the same time.



A muscle is made of many **fibres**. In each fibre there are many **fibrils** *(FY-brils)*. When a fibril is highly magnified two types of structure can be seen. These structures are called **filaments** *(FILL-a-ments)*. They are represented by different colours in the diagram below.





When a muscle contracts, one group of filaments (shown in black) moves in between the other group of filaments (shown in lilac).

You may wish to find out about things which affect the performance of your muscles. Later you could work through Option 1 (Muscular Strength).

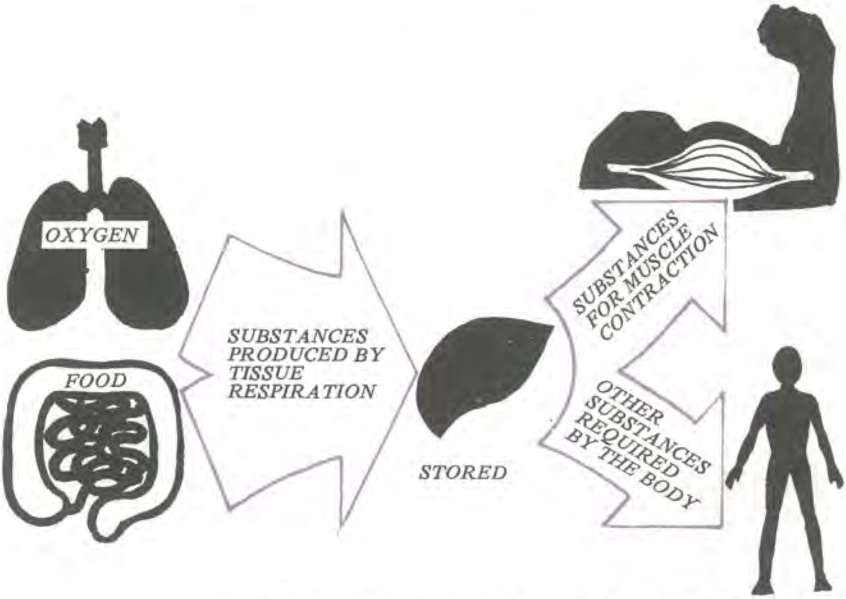
ENERGY FOR MUSCLES

The human body is like a machine in its use of energy. Fuel is burnt in a machine to produce usable energy. The energy in the fuel is changed to other forms of energy such as light, heat, sound and movement.

This process in the body is called **tissue respiration.** Molecules from food are **oxidized** (burnt) in the body to supply the energy required for movement. **Oxidation** takes place in the cells at body temperature.

Only some of the energy made available by tissue respiration is used for movement. Most of it is converted to heat.

The muscles, joints, nervous system, respiratory system and blood system are all important in producing body movement. The diagram below illustrates some of the changes which take place during tissue respiration.


OXYGEN
FOOD
SUBSTANCES PRODUCED BY TISSUE RESPIRATION
STORED
SUBSTANCES FOR MUSCLE CONTRACTION
OTHER SUBSTANCES REQUIRED BY THE BODY

Later, you may like to do Option 3 (Exercise and Fatigue) to find out how exercise affects the blood system.

MEASURING ENERGY

When more energy is needed, more oxygen is required. This can be tested by experiment. To find out the volume of air you breathe, you measure your **rate of breathing** and the **volume of one breath**. The volume of oxygen absorbed depends on the volume of air taken in. To work out how much energy you are using, follow through Activities 4 to 6.

The volume of oxygen absorbed also depends on the proportion of oxygen in the air. Normally air contains only 20 per cent by volume of oxygen.

ACTIVITY 4: RATE OF BREATHING

You will need:

- 1 watch (or clock) with a sweep second-hand.

Sit down quietly for about 1 minute. Hold your forefinger under your nose as shown at left. As you breathe out, you will feel the warm breath on your forefinger. Count the number of breaths you take in 1 minute.

✍ 5 Use the table in your record book to record the number of times you breathe in 1 minute. Repeat this count. Calculate and record the average.

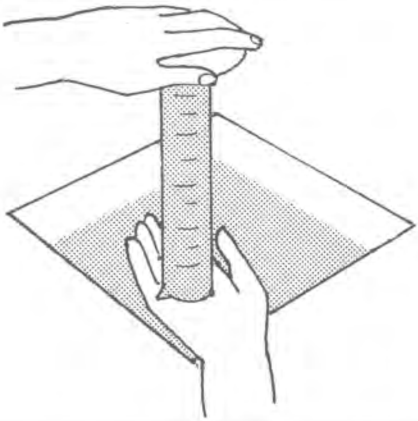
(If you don't know or can't remember how to take an average, refer to ASEP's *Graphing, Averaging and Reading a Scale.*)

ACTIVITY 5:
VOLUME OF AIR IN A BREATH

You will need:
- 1 plastic bag
- 1 sink (or bowl)
- 1 length of tubing
- 1 measuring cylinder, 500 ml.

You will find it easier to work with a partner for this activity.

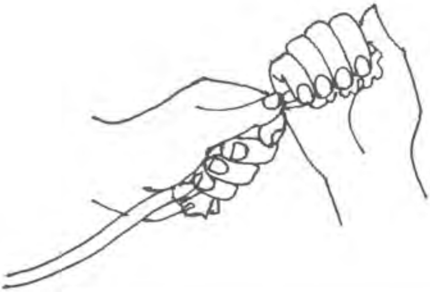
While one partner half fills the sink with water the other can fill the measuring cylinder. The cylinder is to be turned upside down in the sink without letting any water out. To do this, hold one hand over the top of the cylinder, invert its top into the water and take your hand away.



While one partner holds the cylinder so that it does not fall over, the other can continue with the activity.

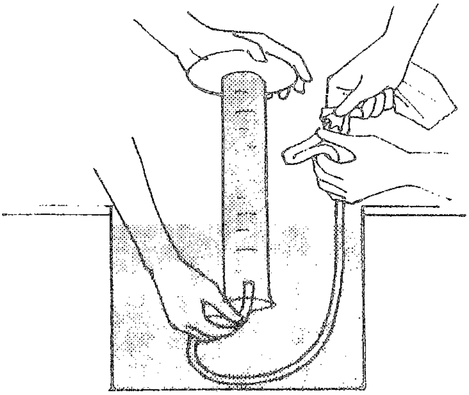
You are going to measure the volume of air exhaled in a normal breath. Sit down and practise breathing through your mouth. Take the plastic bag. You are not to try to blow it up–just expel one breath into it.

Hold the open end of the bag tightly around one end of the tubing. Squeeze the bag so that it is empty of air.

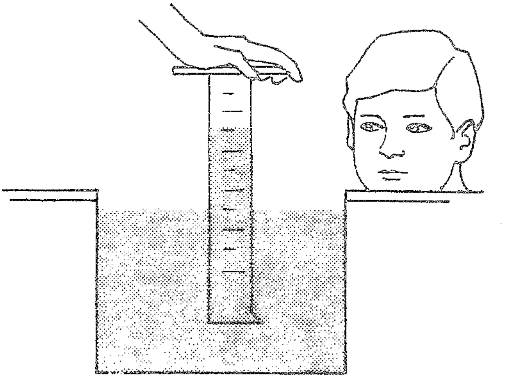


Place the other end of the tubing in your mouth and breathe into the bag.

Bend the tubing over so that no air can escape. Ask your partner to place the end of the tubing carefully under the water and into the measuring cylinder.



Squeeze the bag so that all the air in it passes into the cylinder. Read off the volume of air in your normal breath. This should be easy to do even though the cylinder is upside down.



6 Record the result of two trials. Your measurement will be more reliable if you average the results.

ACTIVITY 6: AVAILABLE ENERGY

From the measurements you have obtained in Activities 4 and 5, you can calculate how much energy is made available per minute. To help you, a sample calculation, together with explanations, is given below.

□ The volume of air you breathe per minute depends on how many breaths you take per minute and how deeply you breathe. The average number of breaths per minute multiplied by the average volume of one breath gives the average volume of air breathed per minute.

e.g. 16 breaths per minute x 0.200 litre per breath
= 3.2 litres of air per minute.

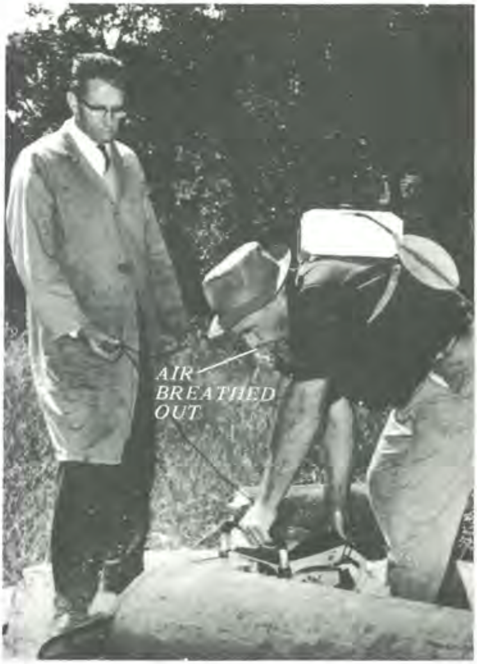
□ About 20 litres of air are breathed in for every litre of oxygen absorbed into the blood. The volume of oxygen absorbed is calculated by dividing the volume of air by 20.

e.g. 3.2 ÷ 20
= 0.16 litre of oxygen absorbed per minute.

□ For every litre of oxygen absorbed, enough food is oxidized to make about 19.2 kilojoules of energy available to the body.

e.g. 0.16 x 19.2
= 3.1 kilojoules available per minute.

7 Repeat the calculations in your record book using the values you obtained.



Measuring energy for sawing.

It is difficult to measure directly the energy **used** in a particular activity.

One method of measuring how much energy is made **available** is to measure the volume of oxygen used in a particular activity.

To measure how much oxygen is absorbed during a particular activity, samples of air breathed out are collected. (For more accurate results the volumes of both the oxygen and the carbon dioxide in the air breathed out are measured.)

ACTIVITY 7: OXYGEN INTAKE AND EXERCISE

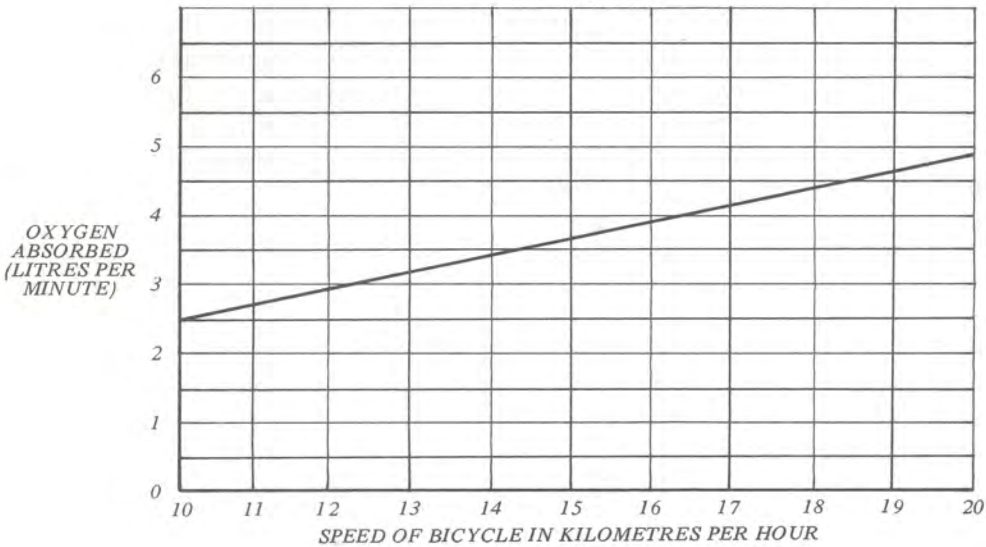
In an experiment people were asked to pedal a bicycle at a steady speed. The volume of oxygen absorbed by each was measured and the average calculated for the group. Their oxygen absorption was also measured when they were pedalling at a number of higher speeds. The graph below shows the results.

Try to use the graph to answer the following questions:

8 What happened to the volume of oxygen absorbed when the speed of pedalling increased?

9 At what rate was oxygen absorbed when pedalling at 13 kilometres per hour?

10 How much energy would have been made available when pedalling at 10 kilometres per hour? (If you have difficulty with this, re-read the last part of the calculation on page 16.)



ACTIVITY 8: ENERGY FOR ACTIVITY

The rate at which energy is made available can be measured. The table below shows the usual energy used by adults in the activities listed. (There is little information on the energy used by children.)

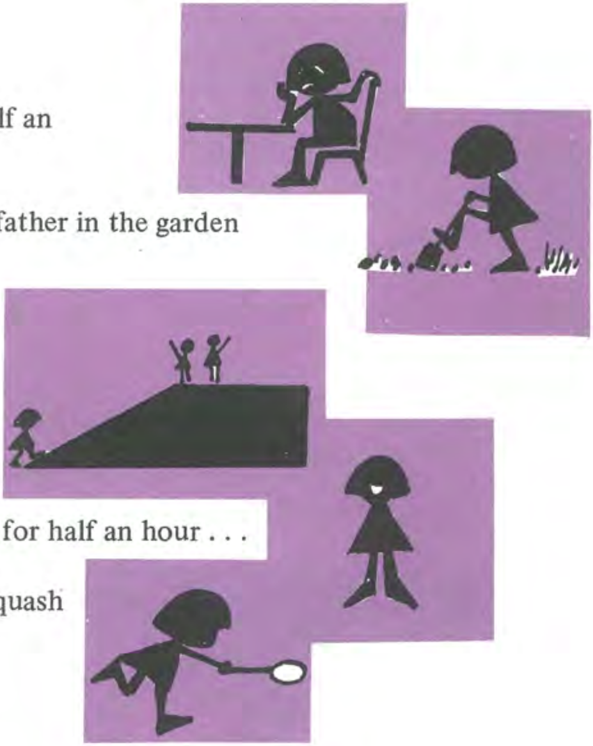
ACTIVITY	OXYGEN ABSORPTION IN LITRES PER MINUTE	ENERGY USED IN KILOJOULES PER MINUTE
LYING DOWN	0.23	4.4
SITTING	0.25	4.8
STANDING	0.31	6.0
LIGHT WORK	0.71	13.6
GARDENING	1.08	20.7
BRISK WALK 6.4 km/h on level ground	1.10	21.1
GOLF	1.18	22.7
MODERATE WORK e.g. pushing a wheelbarrow	1.30	25.0
TENNIS	1.50	28.8
HEAVY WORK	1.75	33.6
BRISK WALK UPHILL	2.25	43.2
BOXING	2.95	56.6
SQUASH	3.05	58.6

Adapted from Fox, D. Nuffield Secondary Science Theme 3, *Biology of Man.* London, Longman Group Ltd, 1971. p.38.

The rate of oxygen absorption is shown in the first column of figures. To calculate the amount of energy released in the body, the figures in the first column were multiplied by 19.2. (Each litre of oxygen absorbed makes available approximately this number of kilojoules.)

11 Use the table opposite and the information given in the next paragraph to work out how much energy Lyndal would have used. (Assume that Lyndal is a young adult.)

Space has been provided in your record book for your calculations.



After doing homework for half an hour, Lyndal became bored.

She went outside to help her father in the garden for 15 minutes.

Then she saw her friends meeting at the club up the hill, so she walked briskly up to join them (4 minutes).

After standing around talking for half an hour . . .

. . . she went off and played squash for an hour.

12 What might happen if the energy you take in from food is

☐ greater than the energy you use?

☐ less than the energy you use?

You may like to discuss these questions with others before writing your own answer in your record book.

You can check your answers by turning to page 82 of this book.

Tissue respiration in the absence of oxygen produces energy and lactic acid. An increase in lactic acid concentration is seen in muscles which have cramped. However, the causes of cramp and the stitch are complex and not fully understood.

FATIGUE

The energy made available by tissue respiration is used to produce many substances required by the body. Some of these substances may be stored in the muscles. They are used when muscles contract.

In a very short sprint, e.g. 50 metres, a runner may take only one or two breaths. He may use energy at a rate of 450 to 600 kilojoules per minute, i.e. 40 to 50 kilojoules in 5 seconds. He cannot get all this energy from tissue respiration during the sprint. He has therefore used energy resources stored in his muscles. After the sprint he will be fatigued and will continue to gasp and pant for some time. He has an **oxygen debt** until he has absorbed enough oxygen to replace the energy borrowed from the substances stored in his muscles.

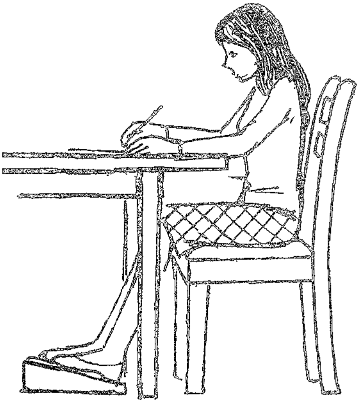
After strenuous exercise there is a drop in performance level. This is termed fatigue. The sprinter may run another 50 metres 10 minutes after the first race—but he takes longer. Training helps delay fatigue and reduce its effects. You can find out more about this in Option 7 (Training).

WORKING FACILITIES

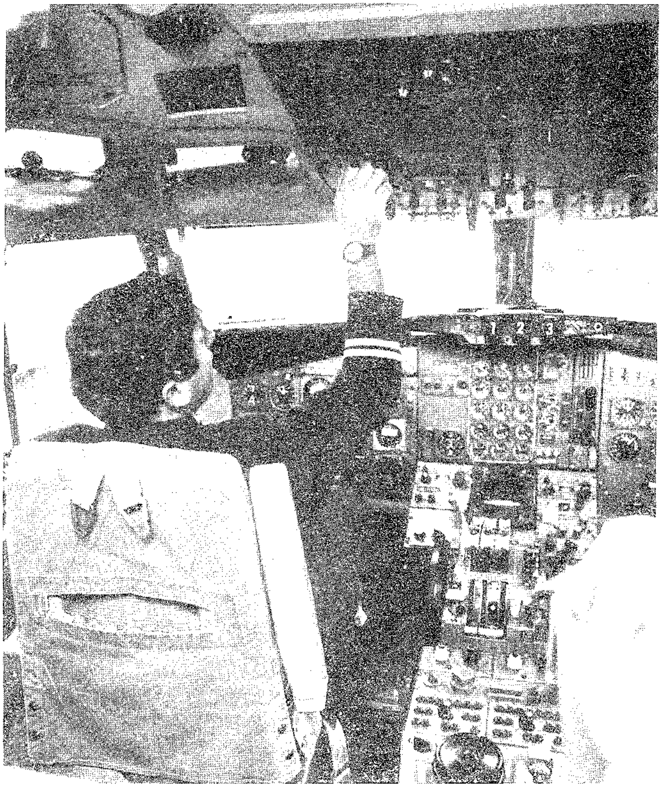
You don't have to exercise to feel tired. Sometimes sitting on a chair or working bent over a table makes you very tired indeed. This is so whenever furniture and other fittings are not designed to suit the body. We should not have to adapt to suit the equipment.

If we are to move comfortably, we need adequate space. By studying the body and how the limbs move manufacturers can decide what work space we need. They must make it safe and easy for us to reach and operate equipment.

Later you may like to choose Option 6 (Design For Performance) to find out more about furniture design and placement of controls.



A foot rest gives a more comfortable sitting position.



The pilot at the controls of a jet aircraft.

TEST YOURSELF—MAN, THE VERSATILE ANIMAL

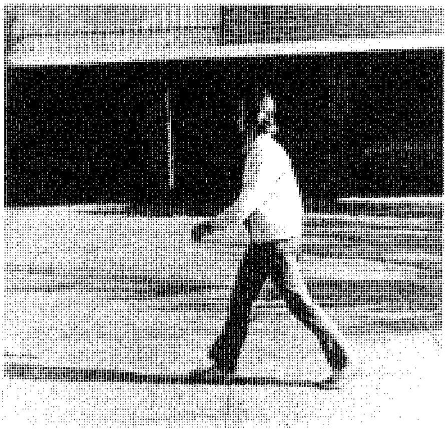
This test is to help you find out if you understand what you have been doing. It is important that all your answers are your own work. It is not a test for marks.

For most questions, you have to choose the best answer from the several answers suggested. In each of these cases, write only the letter of the answer which you choose.

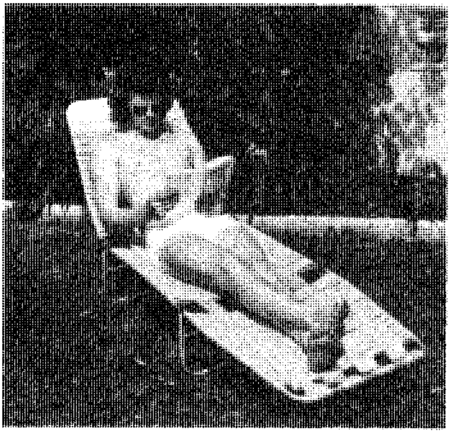
Answer the following questions on page 6 of your record book.

Questions 1 to 3 refer to the photos below.

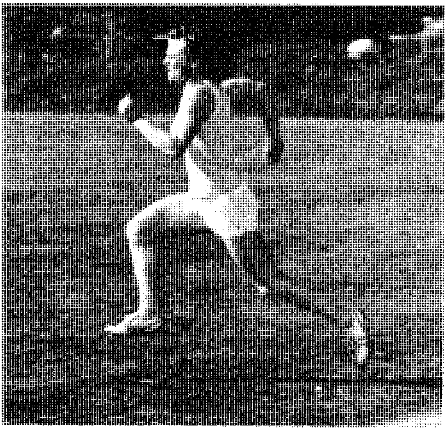
Each activity, A, B, C and D, is done by the same man for one minute.



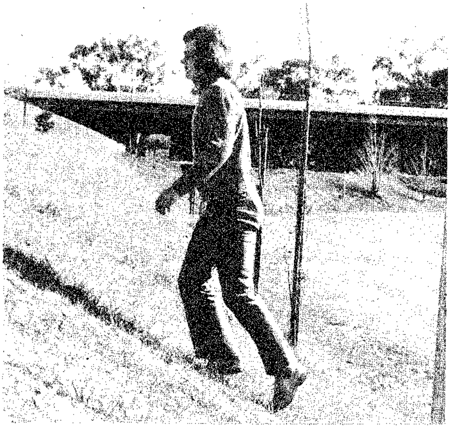
A



B



C



D

1 In which activity would the man use oxygen at the lowest rate?

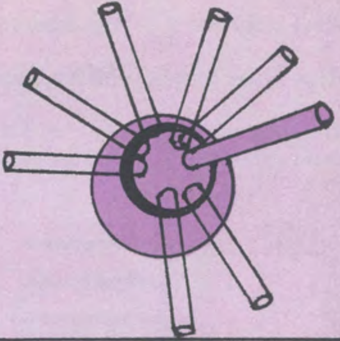
2 During which activity is the man most likely to develop an oxygen debt?

3 In which activity would the man's body probably produce most lactic acid?

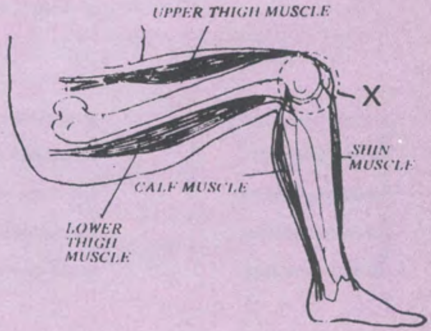
4 The diagram at right shows a ball and socket joint.

At which of the following body locations (one or more) is this type of joint found?

- A Knee
- B Elbow
- C Shoulder
- D Hip



Questions 5 and 6 refer to the photo and diagram below.
The leg of the woman in the photo is represented in the diagram.



5 What is the name of the muscle which would be used by the woman to straighten her leg while she remained seated?

6 The function of the region marked X in the diagram is to

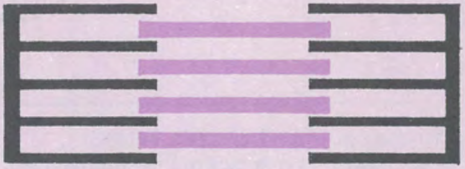
- A provide the nervous stimuli which activate the muscles.
- B permit the leg to bend.
- C contract and pull the muscles taut.
- D store oxidized food molecules.

Test Yourself continued next page

7 What is the name of the structures which attach one bone to another?

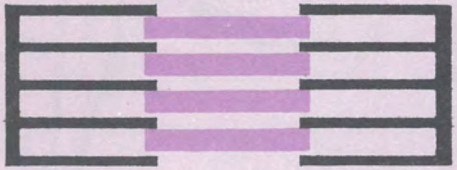
8 What is the name of the structures which attach muscle to bone?

9 The diagram below represents part of a muscle fibril. The lilac and black parts represent the two types of filament.

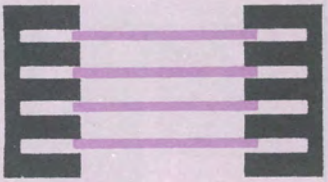


Which one of the following diagrams best represents the muscle fibril in its most contracted state?

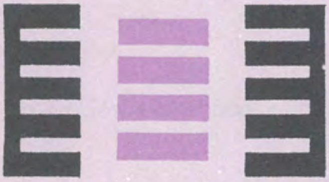
A



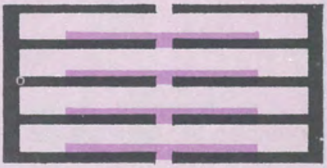
B



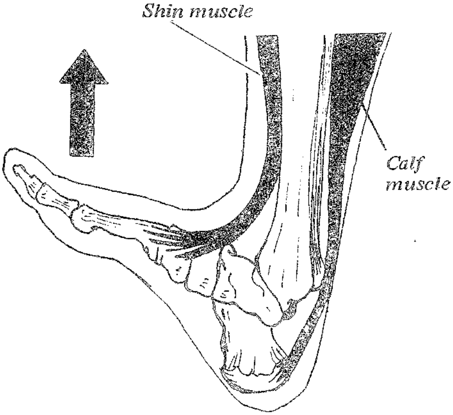
C



D



10 A man moves his foot as indicated in the diagram. Which one of the following actions of the muscle pair is most likely to produce this movement?



- A Contraction of the shin muscle and the calf muscle.
- B Contraction of the shin muscle and relaxation of the calf muscle.
- C Relaxation of the shin muscle and contraction of the calf muscle.
- D Relaxation of the shin muscle and the calf muscle.

11 Which one of the following statements best describes tissue respiration?

- A It is the chemical process which liberates energy from food.
- B It is the burning of food molecules to release energy, most of which is used for movement.
- C It is the absorption of oxygen and release of carbon dioxide in the lungs.
- D It is the release of energy from substances in muscles during contraction.

12 Suppose a person breathes in 100 litres of air over a certain period. About how many litres of oxygen would be absorbed into the person's blood?

A 100
C 20
B 50
D 5

13 A man exercises for ten minutes. During this time twelve litres of oxygen are absorbed into his blood. For every litre of oxygen absorbed by the body about 19.2 kilojoules of energy are released. About how much energy would be released in the man's body in one minute?

Now turn to Check Your Answers on page 83 of this book.

ABOUT THE OPTIONS

Here are summaries to help you decide which options to choose.

OPTION 1:
MUSCULAR STRENGTH . . Page 28

There are different kinds of strength. You can measure your strength in pushing, pulling and jumping. A set of bathroom scales is needed for the activities in this option.

OPTION 2:
ACQUIRING SKILL . . . . . . Page 35

Test yourself–but in a different way. In this option you can practise a new skill and find out how a skill is acquired. You will see why some skills are harder to acquire than others.

OPTION 3:
EXERCISE AND FATIGUE Page 43

Here is an opportunity for you to investigate the effect of exercise on your own pulse rate. You can also discover what happens when the blood supply to active muscles is interrupted.

OPTION 4: THE MECHANICS OF JUMPING .... Page 50

You can investigate jumping–for example, the angle of take-off and the use of the arms and legs. You will also be able to find the centre of gravity of cardboard models and how important the centre of gravity is for movement generally.

OPTION 5: LIFTING AND HANDLING .... Page 59

One in every four industrial injuries is caused by poor lifting, pushing or pulling techniques. You can find out how to prevent back injuries by using good lifting techniques. This is mainly a reading option.

OPTION 6: DESIGN FOR PERFORMANCE .... Page 65

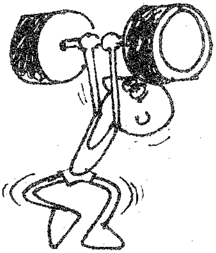
How suitable is the furniture and working space you use? This option involves you in looking at everyday items critically. Perhaps they could be made easier to use.

OPTION 7: TRAINING .... Page 74

In this option you can find out how exercise affects the blood system and the respiratory system. There is also some discussion on training methods.

OPTION

1



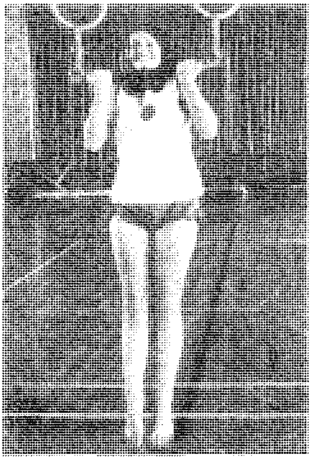
There are different kinds of strength. You can measure your strength in pushing, pulling and jumping. A set of bathroom scales is needed for the activities in this option.

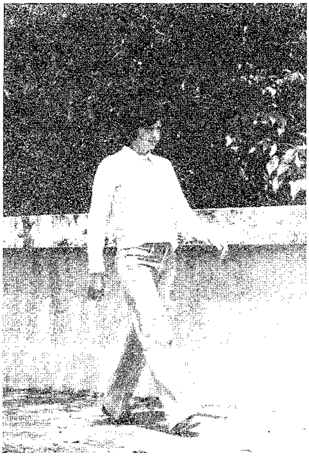
Muscular Strength

It is usual to give names to the different kinds of muscular strength.

Static strength is used when you push or pull but the body does not move. When holding a parcel, pushing against some object which does not move, or merely standing still, you are using static strength. The muscles are contracted even though the body does not move.

Dynamic strength involves movement of the body. The movement is firm and repetitive as in push-ups, pull-ups, swimming, running or just plain walking. The muscles contract and relax as the movement takes place.

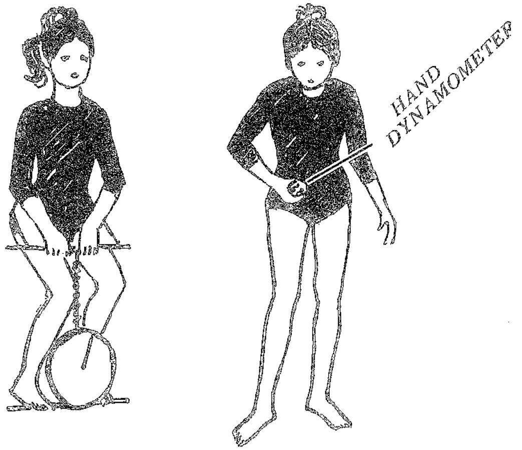




Sometimes you use your muscular strength in one maximum effort, in an almost 'explosive' way. This application, termed muscular power, is used in jumping high and in various throwing events.

Static strength may be measured by finding the force exerted by muscles when they are contracted but not causing movement. Special instruments called dynamometers *(DYN-a-MOM-meters)* are used to record static strength.

You use your muscles in particular ways in different activities. For each activity your static strength measurement will probably be different. In the next activity you will be able to measure your static strength for one group of muscles.



MEASURING LEG LIFT AND GRIP STRENGTH.

ACTIVITY 1: MEASURING STATIC STRENGTH

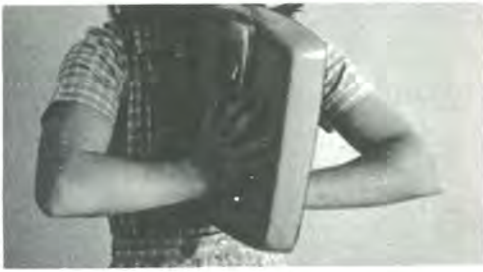
You will need:

- 1 set of bathroom scales.

Have several students, as well as yourself, measure their static strength as shown at right. Read the scale about 5 seconds after the force has been applied.

Make sure that the measurements are taken in the same way each time. This will allow you to compare results.

1.1 Record the results in the table on page 7 of your record book. Note any differences between results and try to explain why they occur.

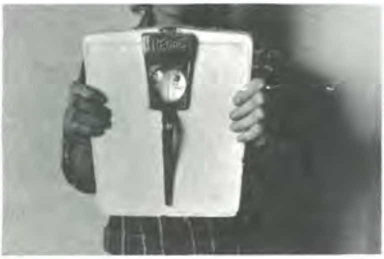


Bathroom scales are calibrated in kilograms but force is measured in newtons. To convert the scale reading to newtons it will be accurate enough to multiply by 10. e.g. 235 kilograms is approximately equal to 2350 newtons.

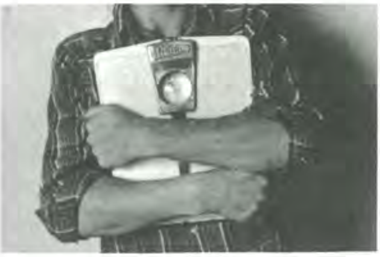
FURTHER ACTIVITIES

1 You could measure and compare

☐ *finger grip strength*



☐ *hug strength*



2 Try to measure and compare static strengths for some of the following:

☐ people whose forearm muscles are of different circumference (compare grip strengths)

☐ children compared with adults (either of the same or opposite sex)

☐ males and females of the same age

☐ the same person on a cold day and on a hot day.

Try to give reasons for your results in each case.

ACTIVITY 2: MEASURING DYNAMIC STRENGTH

Many common exercises are dynamic because movement of the body occurs. Using a dynamometer to measure static leg strength may not indicate the strength needed for weight-lifting. This involves movement and, hence, dynamic strength.

You can try measuring your dynamic strength by counting the maximum number of pull-ups or push-ups you can do without stopping for a rest.

✍ 1.2 Record your results, and those of several other students, in the table in your record book.

✍ 1.3 What comparisons, if any, can be made between your own static and dynamic strengths? Comment on the performance of others, e.g. does a person with high static strength also have great dynamic strength? Try to give reasons for your answers.

Pull-up.

Push-up.

ACTIVITY 3: MEASURING MUSCULAR POWER

You can measure muscular power–muscular strength used in one explosive effort–by finding the height you can reach in a vertical jump.

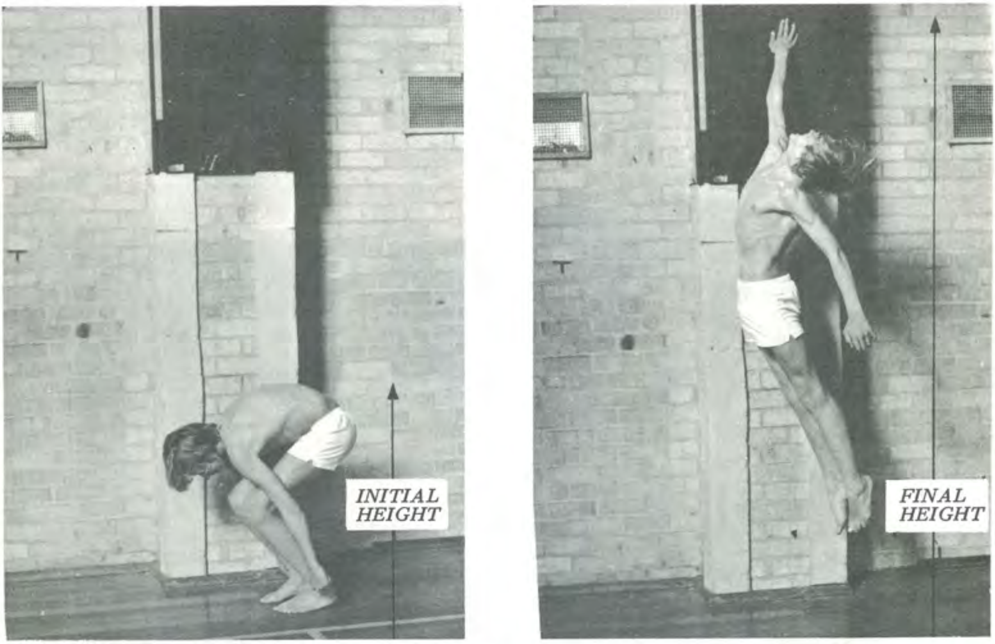
You will need:

- 1 tape measure (or ruler).

The distance covered in a vertical jump is the difference between the final and initial heights.

1.4 Record the distance covered for several students.

1.5 Do those students with more muscular power also have greater dynamic strength than others? Explain your answer.



How to measure the height of a vertical jump.

My you're thin!
Yes-I've been sick!

How often does he use static strength?

WHY BUILD UP MUSCULAR STRENGTH?

Many sportsmen and sportswomen aim to improve their performance by strength training. Muscular strength is one of the factors which contribute to fitness.

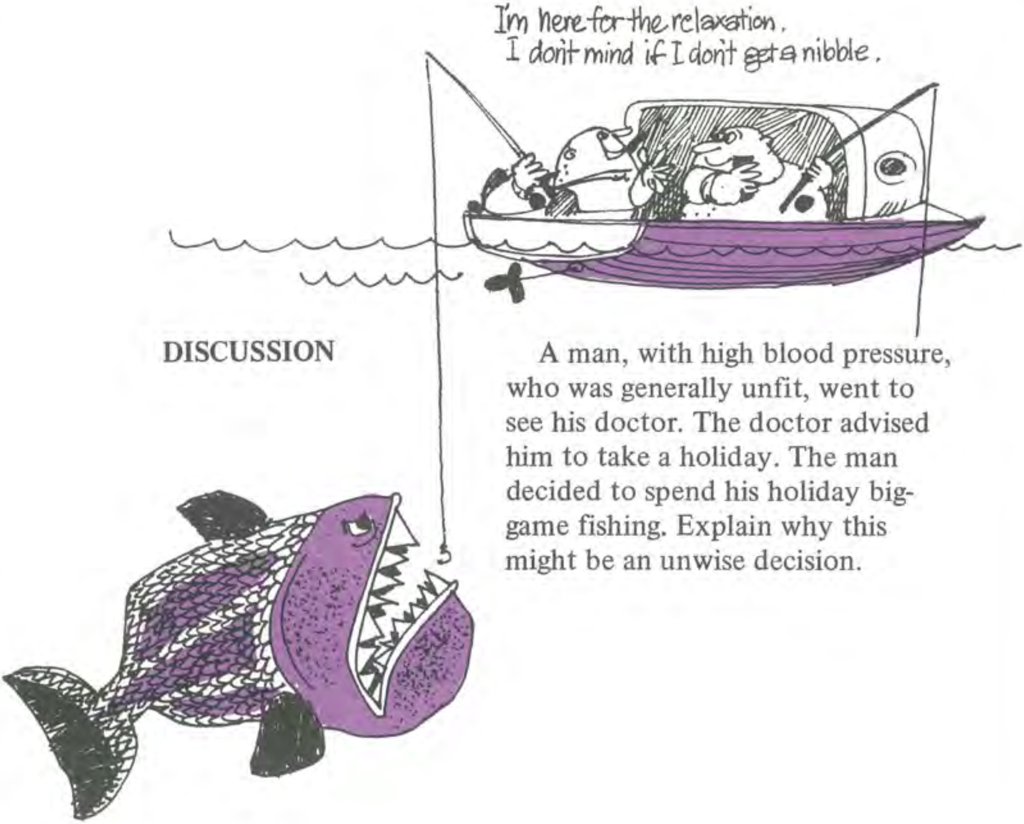
If you have lain in bed for some weeks due to illness, or your arm has been in plaster after being broken, the muscles become soft and shrunken. These muscles can be built up by exercises such as those given by a physiotherapist.

Different activities require specific strength in certain muscles. Well developed shoulder muscles are important for a swimmer. An athlete's performance in the long jump may improve if he exercises to strengthen his leg muscles.

However, muscular strength is more important for the jumper than the marathon runner. In the latter sport, strength is not as important as endurance.

PROBLEMS FOR THE UNWARY

You use static strength in holding a case or bag. Because movement is not involved, it is often not realized that these activities can be dangerous for people who are not fit. The demand for more blood by muscles which are not normally used may put a strain on the heart.


I'm here for the relaxation.
I don't mind if I don't get a nibble.

DISCUSSION

A man, with high blood pressure, who was generally unfit, went to see his doctor. The doctor advised him to take a holiday. The man decided to spend his holiday big-game fishing. Explain why this might be an unwise decision.

FURTHER ACTIVITY

You could test your
- ☐ static strength
- ☐ dynamic strength
- ☐ muscular power

each day for two or three weeks and comment on your results.

You can check your answers by turning to page 85 of this book.

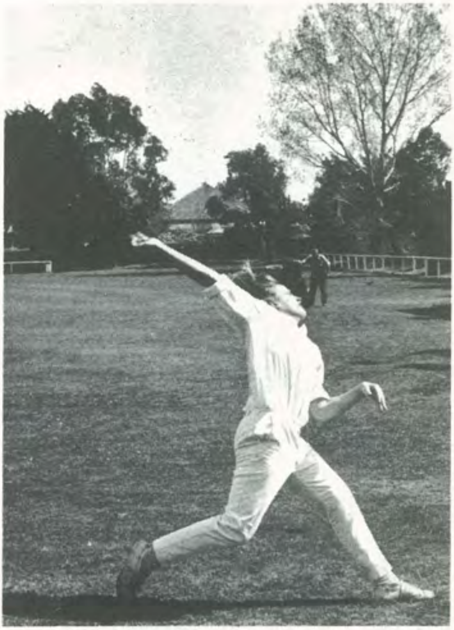
OPTION 2

Test yourself–but in a different way. In this option you can practise a new skill and find out how a skill is acquired.
You will see why some skills are harder to acquire than others.

Acquiring Skill

An activity may involve a specific skill–for example, performance of a one-handed balance. It may be a collection of skills, such as those used by a cricketer or a pianist.

A specific skill–a one-handed balance.



This bowler uses a series of skills.

A skilful performer cuts down unnecessary movements, increases the speed, and reduces the number of errors involved in performing a particular activity. However, a skill has to be acquired.

ACTIVITY 1: ACQUIRING A SKILL

How good are you at . . .

. . . balancing, a ruler on your finger, chin or forehead

. . . juggling three balls at once

. . . learning a simple tune?

This activity takes a week to complete. Read it through first so that you know what you are to do. While you are still getting results you can go on with the rest of the option.

Choose one of the activities shown in the illustrations, or one which is similar. Don't select one which you find quite easy to do. Work out a way to measure your performance. Practise the skill five times. Do it once more and record the results of this last trial. You are going to measure your performance each day for a wee to find out how much you are improving.

So that you can compare results you should do the same amount of practice between each trial. If you like you can practise the skill at home rather than at school.

✍ 2.1 Record your achievement for each day. Use the table on page 8 of your record book.

✍ 2.2 What do you notice concerning the effect of practice on the acquiring of your chosen skill? When were you improving at the faste rate? What reasons can you suggest for this? You may wish to discuss these questions with others before writing your answers.

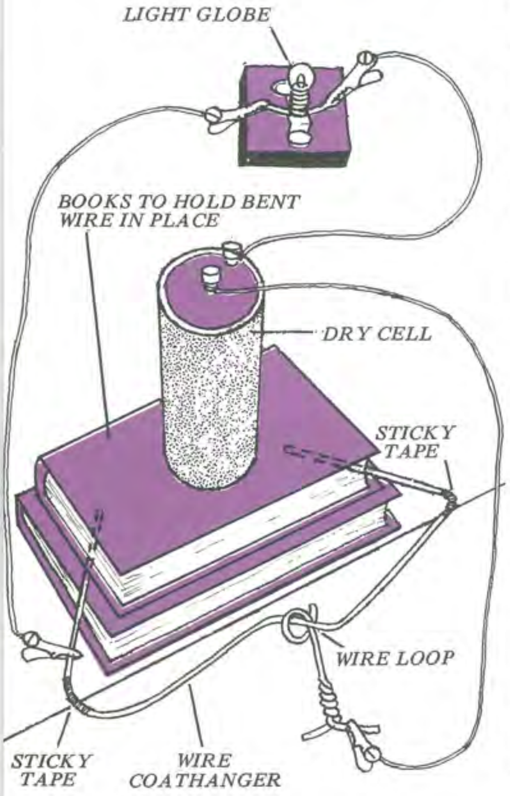
Your skill may improve if you kno where you are going wrong. In the next activity you can find out how the knowledge of results affects learning.

ACTIVITY 2: SIGHT UNSEEN

You will need:

- 1 kit of 'skill apparatus'
- 1 handkerchief (or scarf).

Look at the apparatus and identify its parts by comparing it with the illustration at left.



In this activity you are to find out how skilful you can become at guiding the wire loop along the bent wire without touching it. If the wires do touch, the electric circuit will be completed and the light will glow. You won't get an electric shock when the wires touch.

Guide the loop along the wire to see what happens when they touch. Only do this once.

Have your partner tie the handkerchief over your eyes as a blindfold. If you can see when the light comes on you will need to adjust the blindfold.

You are doing the hardest activity first. Don't be upset if you make mistakes–it is expected that you will.

As carefully as you can, move the loop along the wire trying not to let them touch. Your partner should note the number of times the light glowed, and then shift the loop back to the start. Repeat the skill five times before you remove the blindfold.

Change places so that your partner can try the activity.

2.3 Record the results of each trial on the table on page 9 of your record book.

ACTIVITY 3: LOOK AND LEARN

When blindfolded you probably found it difficult to do Activity 2 without error. In this activity you will again use the apparatus as for Activity 2 but you won't be blindfolded. Again, move the loop along the wire trying not to let them touch.

Do five trials, note the number of times the light glows for each trial.

Change places and have your partner repeat the activity.

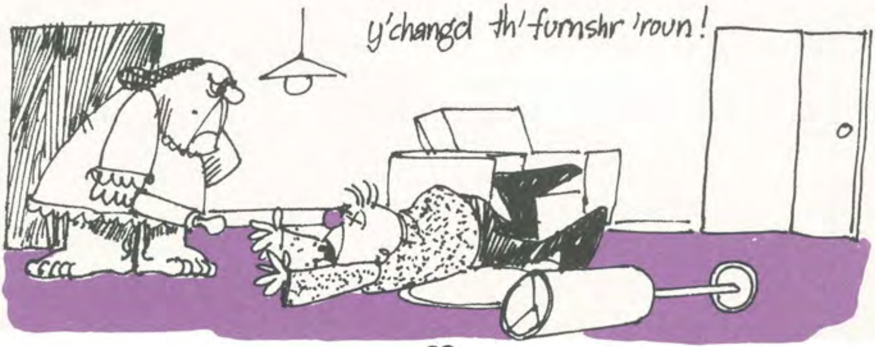
✍ 2.4 Record the results of each trial. Consider the effect of being able to see what you are doing. Try to explain your results.

ACTIVITY 4: SPEED AND LEARNING

You will need:
- 1 kit of 'skill apparatus'
- 1 watch (or clock) with a sweep second-hand.

This time try to move the loop along the wire as quickly as possible without allowing the wires to touch. You could have a competition with your partner to see which of you can perform the skill in the shortest time, with the fewest errors. You could select your best result out of five trials.

✍ 2.5 Record the result of each trial. What is the effect of trying to perform the skill quickly? Try to explain your answer.


y'changd th'furnshr 'roun!

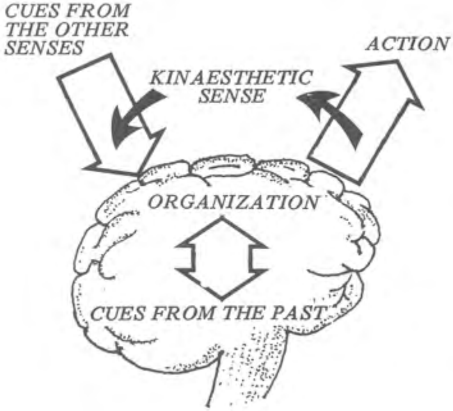
Knowing how you have performed helps you to improve a skill. You can learn how to hit a tennis ball where you want it to go, or how to apply mascara without making a mess, or how to thread a needle.

Responding to cues.
(Photo by courtesy of The Sun.*)*

To be able to use a skill well depends partly on being able to respond in the right way to cues (messages from both inside and outside the body). External cues are perceived by senses such as sight, touch, hearing and balance. The senses of taste and smell may be used in learning skills, as in wine tasting.

There are also special receptors, located in the muscles and tendons, which respond to internal cues. These tell you where your body parts are in relation to one another. It is this **kinaesthetic** *(KYN-es-THET-ick)* sense which, for example, enables you to direct a spoonful of soup into your mouth even when your eyes are closed. The kinaesthetic sense assists in making your movements more co-ordinated.

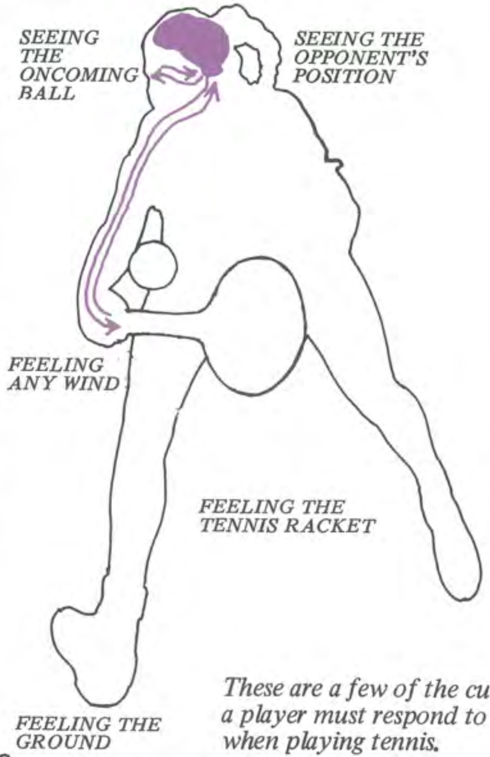
USING CUES



The following is a simplified way of looking at the processes involved in the performance of any skill. Initially the brain receives the cues by way of the various senses. Here the cues are organized and compared with past experiences. The brain then decides on the best course of action and sends the appropriate stimuli to the muscles. The response of the muscles may provide further cues which may modify the course of action.

The greater the number of decisions which have to be made, the longer it takes for the brain to decide on the best course of action. You can find out more about this in the next activity.

(Photo by courtesy of The Age, *Melbourne.)*



These are a few of the cue a player must respond to when playing tennis.

ACTIVITY 5: CLUBS, DIAMONDS, HEARTS, SPADES

You will need:
- 1 pack of playing cards
- 1 watch (or clock) with a sweep second-hand.

In this activity the decisions to be made relate to the number of ways in which the cards are to be sorted. You will find it easier if a partner times you for each sorting procedure.

Each time start with a full pack of 52 cards, mixed thoroughly. Hold the pack face down in one hand. With the other hand, turn the cards over, one at a time, and place them in their correct piles. After you have tried sorting them into each of the arrangements illustrated, let your partner try while you time him.

2.6 There is a table on page 10 of your record book on which to record the results.

Suggested arrangements:

two piles: red cards, black cards

four piles: clubs, diamonds, hearts, spades

six piles: red picture cards, black picture cards, clubs, diamonds, hearts, spades.

2.7 Which arrangement did you sort most quickly and accurately? Why do you think the other arrangements took longer to sort? What happens when you try to sort the cards more quickly?

You are continually learning new skills. These may be completely new skills such as how to use the apparatus needed in Activity 2. They may be an addition to already acquired skills such as better techniques in playing games or musical instruments. The more practice you have the better will be your performance, up to a point.

In more complex activities the brain receives more cues and it takes longer to sort the information. Practising an activity may result in a shortening of the 'sorting time'. That is why you need to practise a skill in order to perform well.

DISCUSSION

A much quoted saying is 'Practice makes perfect'. Is this statement true? Could the statement 'Practice makes imperfect' be just as true? Support your answers with examples where possible.

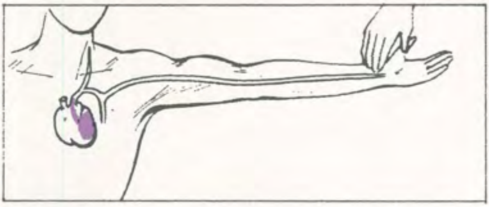
You can check your answers by turning to page 85 of this book.

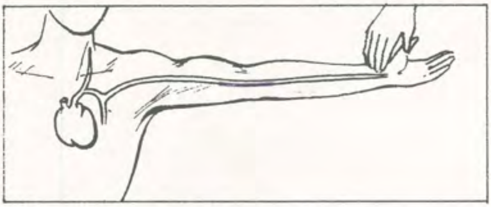
OPTION 3

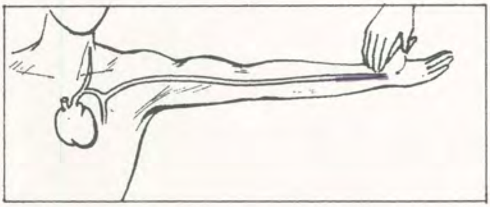
Here is an opportunity for you to investigate the effect of exercise on your own pulse rate. You can also discover what happens when the blood supply to active muscles is interrupted.

Exercise and Fatigue

☠ Warning: Any student with a heart complaint should not attempt the activities in this option







Blood carries compounds derived from food and oxygen to all the cells of the body. But, like any other liquid, blood needs to be pushed to make it flow. This push is provided by the heart.

In some parts of the body you can feel rhythmic throbbing–the pulse. The pulse can be felt where an artery (a blood-vessel carrying blood away from the heart) passes over a bone or some other firm structure. Such places are found in the wrist, the crook of the arm, the temple and the side of the windpipe.

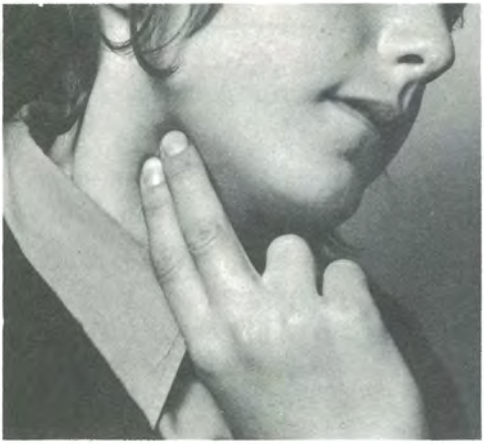
Before finding out the effect of exercise on the pulse rate you need to be able to find the pulse.

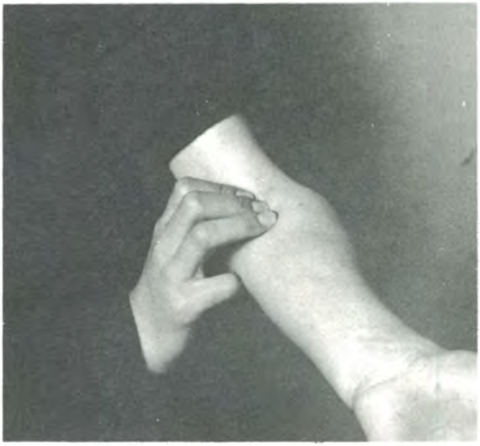
ACTIVITY 1: FINDING THE PULSE

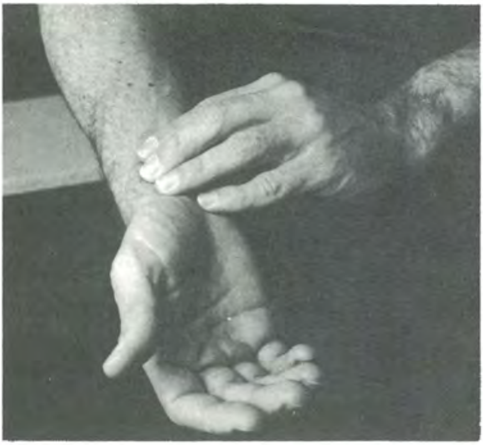
You will need:
- 1 watch (or clock) with a sweep second-hand.

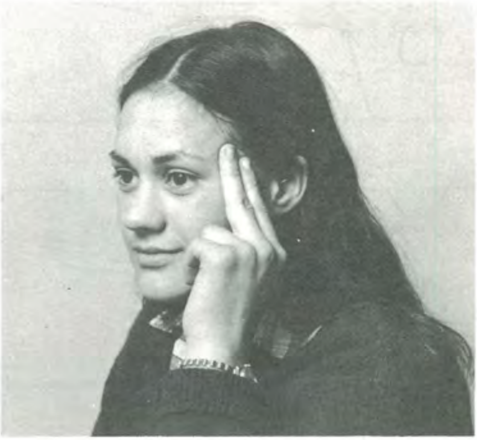
Look carefully at the photos below. Then find your own pulse. Probably you will find the pulse in your neck most easily, but use whichever method you find easiest. Be sure that you can locate your pulse quickly and easily.

Sit down for one minute, then measure your pulse rate during the next minute. Take two separate counts and average your results. This is your resting pulse rate.









3.1 Record your resting pulse rate in the table on page 11 of your record book.

ACTIVITY 2: THE PULSE RATE AND EXERCISE

You will need:
- 1 watch (or clock) with a sweep second-hand
- 1 chair (or stool) from 30 to 40 centimetres in height.

You will need to do a standard exercise so that your results may be compared with those of other people.

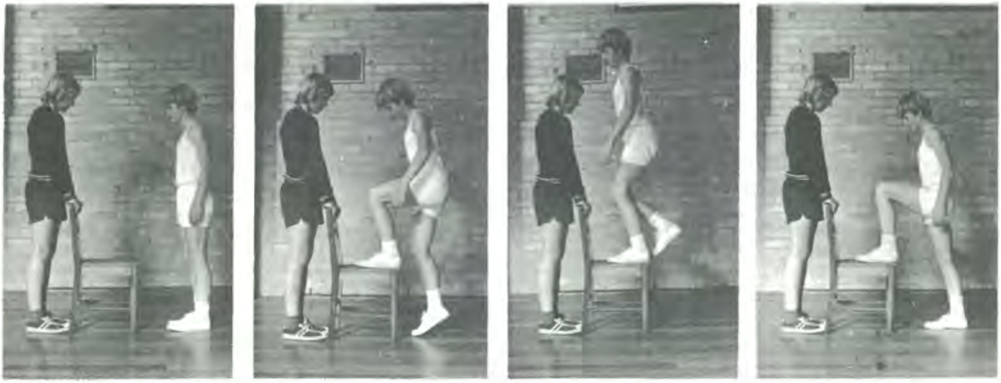
In this exercise you step up and down on a chair as shown in the photos below. You will need to work with a partner who should hold the back of the chair firmly to prevent its slipping while you do the exercise. The cycle of movements should take four seconds. This means you will be stepping up and down 15 times per minute. Try out the rhythm first. Your partner can help by timing you from the watch and counting aloud '1, 2, 3, 4, 1, 2, 3, 4, 1, 2, . . .'.

Rest for a minute or two before beginning the exercise, then do the exercise for three minutes. Immediately at the end of the three minutes begin to count your pulse. Count it for the first five minutes after you finish. Your partner can record the readings you call out at the end of each minute.

3.2 Record your readings in the table in your record book. Should you repeat the exercise and average your results? If you repeat, you will need to wait until you are rested.

Change places with your partner. After he has had his turn you should be rested enough to repeat the exercise if you wish to do so.

3.3 Record your partner's results. If others have done this activity you could also record their results.



Activity 2 continued next page

only two more minutes to go, mum

If you can get some adults to do this activity you could record their results. Make sure they are 'fit' before beginning; such activity could be dangerous for them.

✍ 3.4 Does your resting pulse rate vary very much from those of other people? What is the maximum difference between resting pulse rates?

✍ 3.5 Did your pulse rate, as taken immediately after exercise, vary very much from those of other people? Did you notice any difference between pulse rates of adults and children? What is the maximum difference between pulse rates immediately after exercise?

✍ 3.6 Plot your own and your partner's results on the graph in your record book. Use the graph to estimate how long your heart takes to return to the resting pulse rate. In what way does the heart help the body by beating faster during exercise?

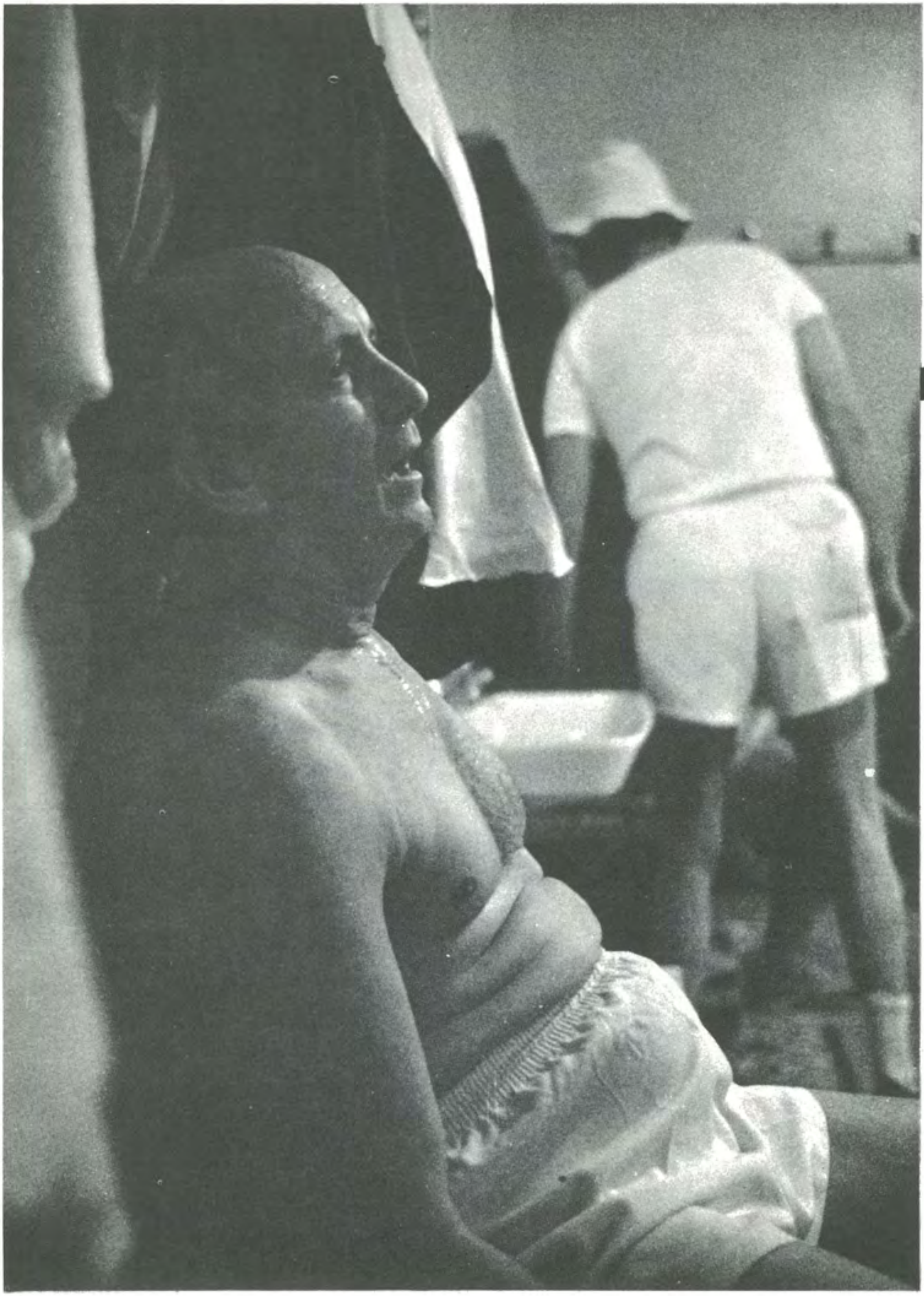
now we'll try a faster rate, mum

FURTHER ACTIVITY

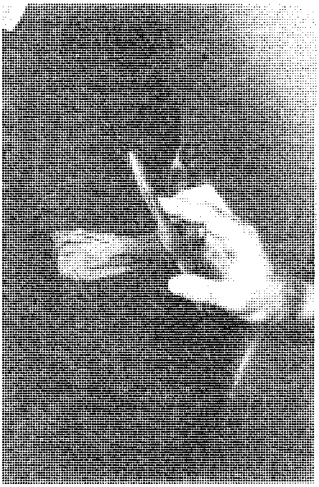
You could repeat the same exercise as in Activity 2 but at a faster rate. If everyone steps up and down at the same rate the results could again be recorded and compared.

When the exercise is repeated at a faster rate you would probably find that the pulse rate went higher and the recovery time (time taken to return to your resting pulse rate) was longer. The recovery time of different individuals will vary; it depends upon their fitness.

ACTIVITY 3: FATIGUE



Activity 3 continued next page



The tourniquet should not be left on for longer than 10 minutes. Blocking the blood supply to the arm can be harmful.

You will need:

- 1 handkerchief
- 1 pencil (or ball point pen).

Ask your partner to sit and rest both forearms on the table top. You are going to place a tourniquet around your partner's left arm. Loosely tie a handkerchief around his upper arm. Place a pencil through the tourniquet.

Find your partner's pulse in his left wrist. Twist the pencil and the handkerchief until the pulse can no longer be felt. If a wrist pulse can still be felt you must tighten the tourniquet further.

When the wrist pulse has been stopped your partner can begin. He is to open and close both hands at the same time and keep doing this at a steady rate, e.g. once per second. This action must be done properly. Do not squeeze the hands closed—just make the fingers touch the palm. Make sure the fingers are fully straightened when the hand is opened.

You are to count the number of times your partner closes his hands. When he first feels pain in his left arm he should tell you, and continue with the activity. Note down the number of times he has closed his hands to this point—continue to count also. Your partner is to keep going as long as he can use his left hand. Release the tourniquet and note the total number of times he closed his hands.

✍ 3.7 Record the results in the table. Now change places, repeat the activity and again record your results.

✍ 3.8 During the activity, what sensations did you experience in your

☐ left arm?
☐ right arm?

Try to explain the sensations you noticed.

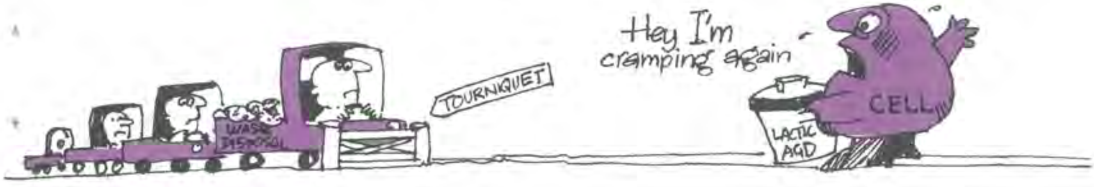
With the blood-vessels blocked, oxygen is not being made available for tissue respiration.

If the muscles are to operate in opening and closing the left hand, they must use some of the chemicals stored in the muscles. (See page 20.) At the same time lactic acid is being produced. With the blood-vessels blocked, continued activity will result in fatigue, and sometimes cramp.

A common way to treat cramp is to rub the affected part vigorously. This warms the immediate area and causes the blood-vessels to enlarge a little, thus increasing the volume of blood flowing through them. You have probably tried this simple remedy yourself.

The harder the body works, the greater is its demand for energy. This, in turn, means that the oxygen intake for tissue respiration must increase and thus the pulse rate usually goes up. The increased pulse rate results in oxygen being delivered to the cells at a faster rate and a quicker removal of wastes. If the blood supply of a muscle is blocked then wastes will accumulate. The accumulation of wastes in the muscles may be one of the factors responsible for fatigue.

If you are interested in fitness and training you may like to try Option 7 (Training).



You can check your answers by turning to page 86 of this book.

OPTION

4

You can investigate jumping–for example, the angle of take-off and the use of the arms and legs. You will also be able to find the centre of gravity of cardboard models and how important the centre of gravity is for movement generally.

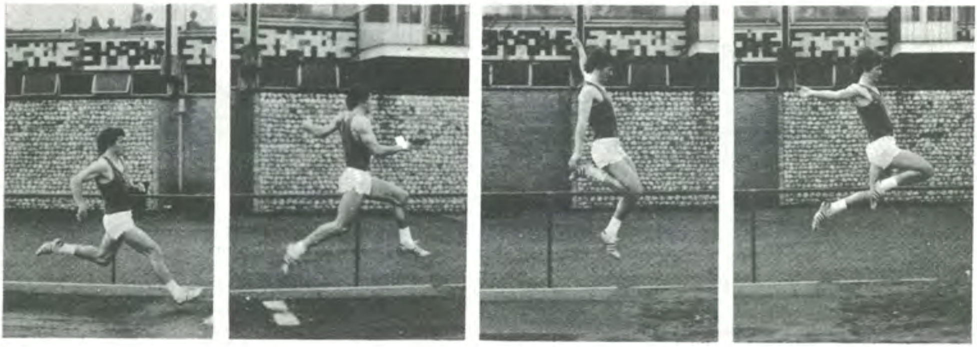
The Mechanics of Jumping

ACTIVITY 1: LONG JUMPING

He covers a greater distance this way

This activity will help you find out some of the factors involved in a long jump. You will need to work with at least one other student.

You are each to try to jump as far as you can. (If space is limited you could try a standing broad jump.) Observe each jumper closely. As they jump, look for the points mentioned on the page opposite. If necessary, ask them to repeat the jump.



Points to look for:

☐ Where are the legs, in relation to the hips, after the jumper leaves the ground?

☐ How are the arms and legs arranged just before the jumper lands?

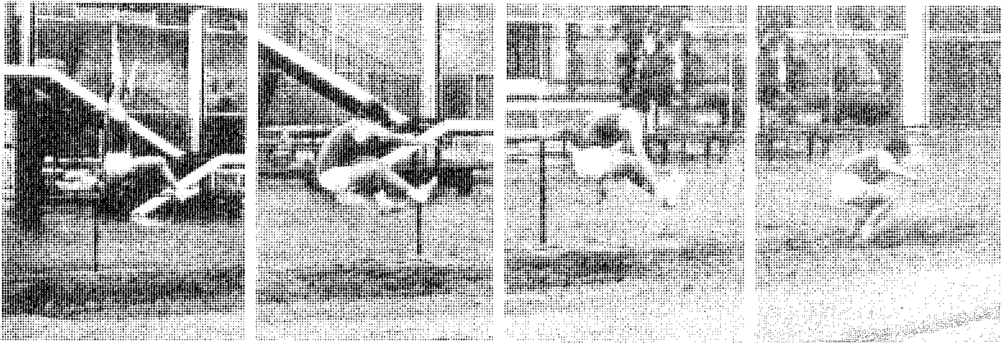
☐ What are the motions of the arms and legs as the jumper lands?

4.1 Space has been provided on page 13 of your record book for you to write a summary of your observations.

A jump takes place quickly. It is not easy to observe everything that happens. The 'stills' below may help you in analyzing a jump. Look at the photos and check them with the points in the list. Also check your answers to 4.1. (See page 86.)

To jump a long distance the athlete must have a fast run-up and also be able to get his body into the air. Like anything else, his body is attracted toward the centre of the earth. It takes effort to overcome the force of gravity.

In analysing a jump, it helps to identify a point through which all a jumper's weight seems to act. This point is called the centre of gravity.



ACTIVITY 2:
FINDING THE CENTRE OF GRAVITY

You will need:
- 1 set of cardboard models (long jump)
- 1 pair of scissors
- 1 length of cotton thread
- 1 nail
- 1 needle.

A chart is pinned on a board. If all but one pin is removed the chart swings around so that it is supported by the pin. Its weight acts along the vertical line down from the pin.

Cut out one of the models.

Push the needle through the model at any point. If the model is hanging freely, its centre of gravity will be somewhere directly beneath the needle.

Tie one end of the cotton thread to the needle and tie the other to the nail. The nail will now hang vertically down from the needle. Draw the vertical line formed by the thread on your model.

Push the needle through some other point of the model. Again, it will swing so that it is hanging from the needle. By using the nail and cotton you can again draw the vertical line along which the weight acts.

The point where the two lines cross is the only point which was directly below the needle each time. This point is called the centre of gravity.

Find the centre of gravity for each of the models.

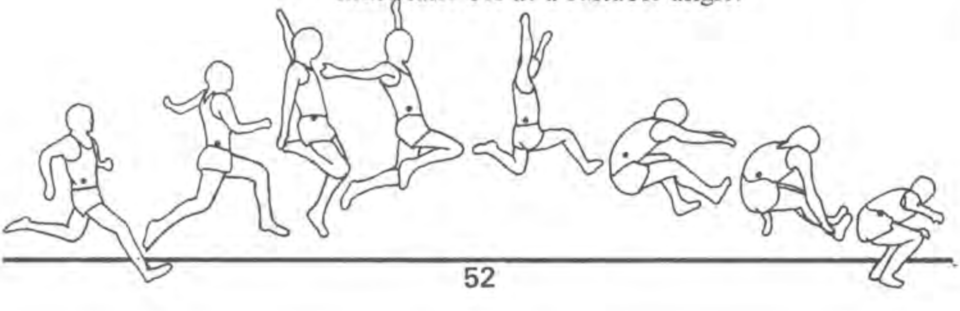
Look at the illustration below and arrange your models in a similar way on a table.

4.2 Use the models to help you answer the following questions:

☐ Describe the path taken by the centre of gravity during the jump.

☐ At approximately what angle to the horizontal does the jumper leave the ground?

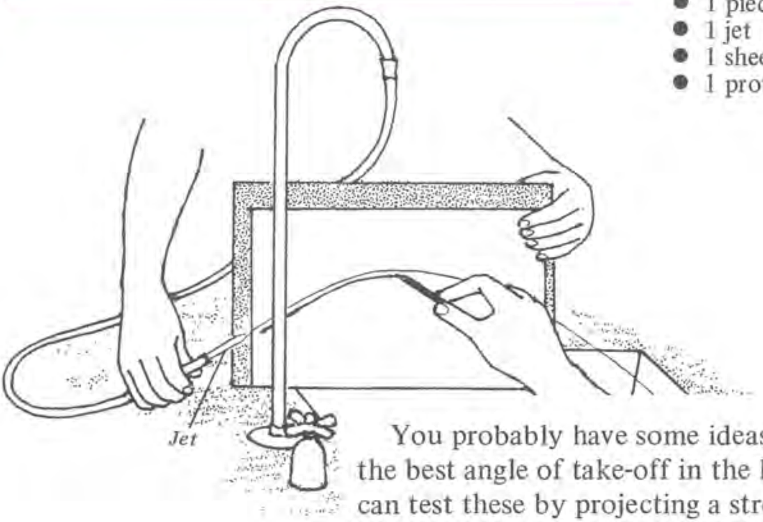
In the long jump the aim is to cover the maximum possible distance. To do this the jumper must take off at a suitable angle.



ACTIVITY 3: THE ANGLE OF TAKE-OFF

You will need:

- 1 sink (or bucket)
- 1 piece of tubing
- 1 jet
- 1 sheet of white paper
- 1 protractor.



You probably have some ideas about which is the best angle of take-off in the long jump. You can test these by projecting a stream of water, under constant pressure, at different angles. This will show the relationship between the angle of projection (take-off) and the distance travelled.

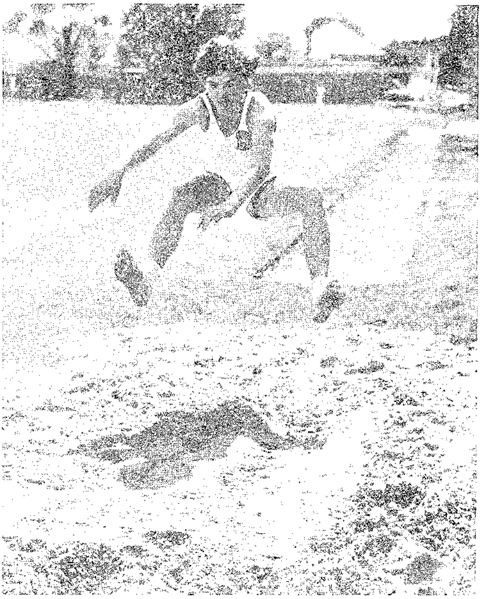
Set up the equipment as shown above. You will need to work with a partner.

One person holds the jet on the edge of the sink. Carefully turn on the tap until the stream of water strikes the sink about 5 centimetres below the opposite edge. Once this has been done, don't alter the water pressure or move your wrist. The other person sketches the path taken by the stream of water. The paper should have a firm backing such as a sheet of cardboard or a book.

By raising or lowering your fingers, alter the angle at which the jet is held. Again sketch the path the stream of water takes. Repeat for a number of different angles of the jet.

4.3 What would be the best take-off angle for a long jump, i.e. at which angle of projection would the greatest horizontal distance be covered? Use the illustrations at the bottom of page 52 to measure the actual angle of take-off. Why do you think there is such a difference between the two values?

A broad base for landing.

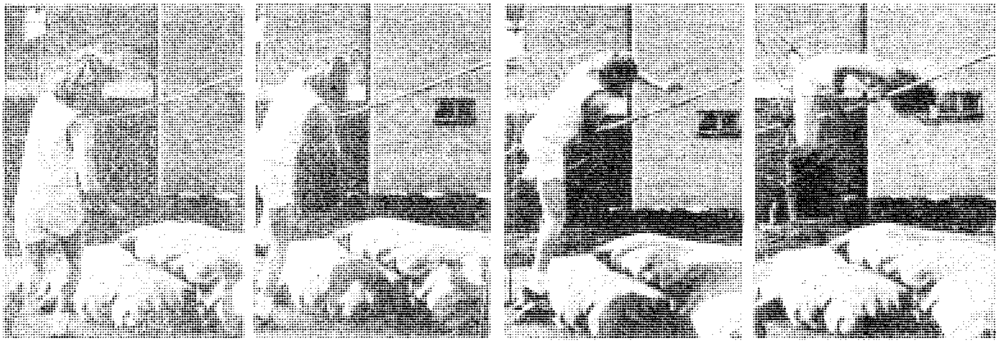


Distance in a long jump is measured from the front of the take-off board to the nearest mark made by the jumper. By falling back the jumper would decrease the distance he had covered.

Notice the position of the jumper's body and limbs as he lands. If the vertical line from the centre of gravity is outside the base (the area formed by the feet) the jumper will fall over. On landing, the jumper's feet are apart. His arms and legs are thrust forward so shifting his centre of gravity forward and he is less likely to fall back as he lands.

4.4 What would happen if, in trying to get maximum distance, he thrust his feet too far forward?

The points which you have studied in long jumping may also be applied to a variety of other movements. Even though there are different techniques, you can analyse high jumping in a similar way.



ACTIVITY 4: HIGH JUMPING

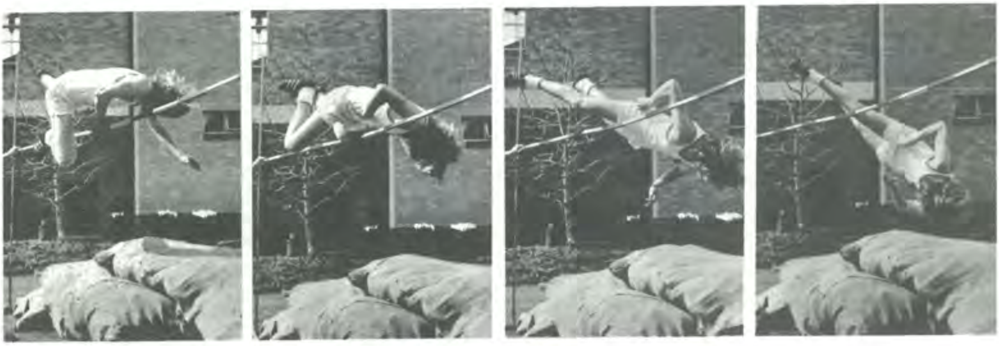
I would have liked to have been a high jumper like you, but I had the wrong centre of gravity

The high jumper in the photos below is using a style known as the straddle. Look at the photos carefully.

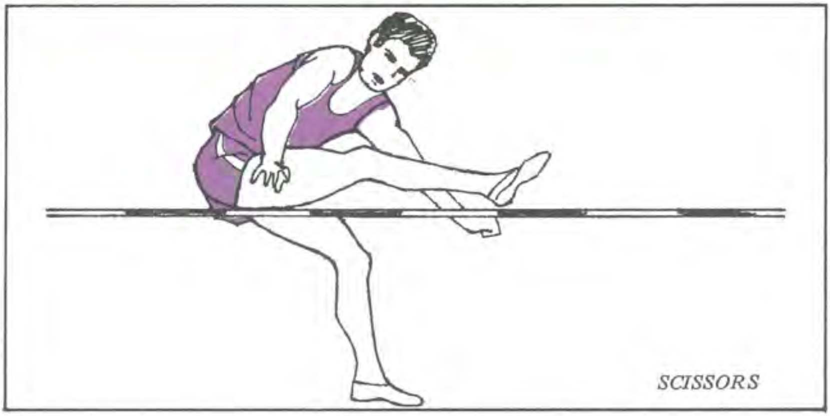
4.5 At approximately what angle to the horizontal is the jumper leaving the ground? Describe the movements made by his centre of gravity during the jump. This information can be marked on the figures on page 14 of your record book.

A high jumper uses his energy to lift his centre of gravity. The further the centre of gravity has to be lifted, the harder it is to clear the bar.

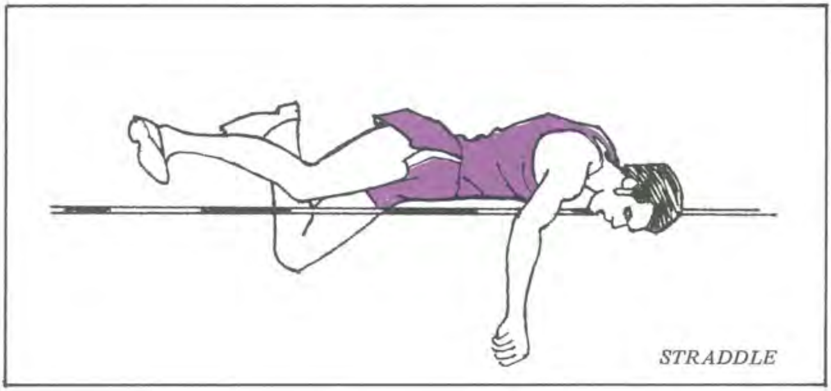
4.6 From your results in Activity 3, suggest what take-off angle would allow the jumper to clear the bar at the greatest height.



ACTIVITY 5: WHICH IS THE BETTER STYLE?



SCISSORS



STRADDLE

You will need:

- 1 set of cardboard models (high jump)
- 1 pair of scissors.

Each model shows the high jumper just as he is clearing the bar. In both cases he has jumped the same height, the only difference is in the style being used.

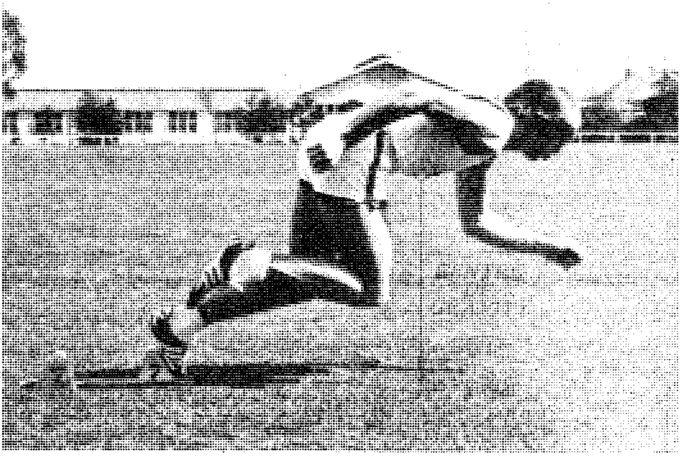
4.7 Find the centre of gravity for each model. Mark its position on the diagram on page 15 of your record book. For which style has the jumper had to use less energy to clear the bar? Give reasons for your answer. Are there any other high jumping styles that might be better than either the scissors or the straddle? In what ways are they better?

In jumping events it is necessary that the centre of gravity be lifted away from the ground. In running events less energy is expended if the centre of gravity does not move up and down. This is particularly so for events such as hurdling.

Inexperienced hurdlers often try to *jump* over the hurdles. Because they have to continually lift their centre of gravity, they soon become tired. A good hurdler simply lifts his legs and lowers his arms and body as he *runs* over the hurdles. For a runner the centre of gravity stays the same distance from the ground.

However, in a sprint start the vertical line from the runner's centre of gravity is in front of his feet. When he lifts his hands from the ground he begins to topple forward. This forward motion helps him in his start.

4.8 Someone said that walking was 'falling over at every step'. Compare this statement with the description of a sprint start and explain what the person meant.

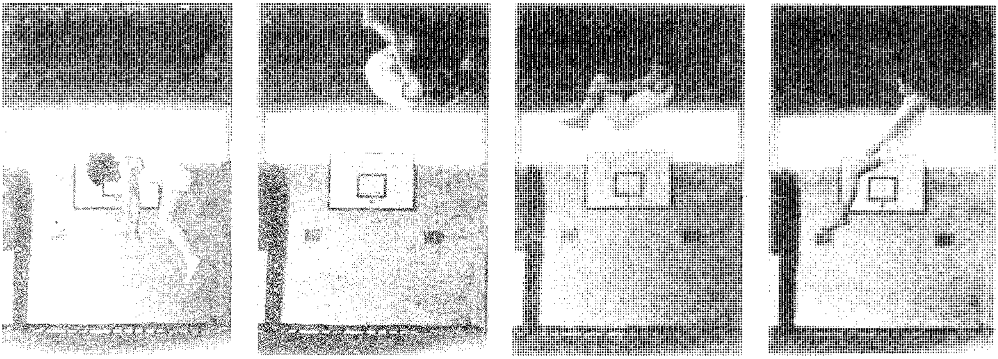


Leaving the blocks in a sprint start.

FURTHER ACTIVITIES

1 Analyse the movements necessary to achieve good results in throwing the discus or in putting the shot. Relate these movements to both the centre of gravity of the discus or shot and the angle at which they should be projected.

2 Ballet leaps and trampolining stunts are performed while the athlete is in the air. In what ways does each manage to gain more time in the air?

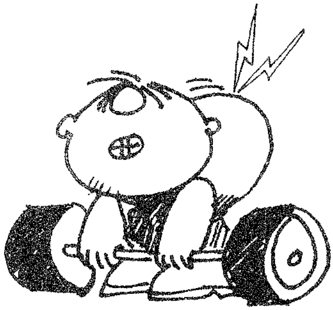


A forward somersault.

You can check your answers by turning to page 86 of this book.

OPTION

5

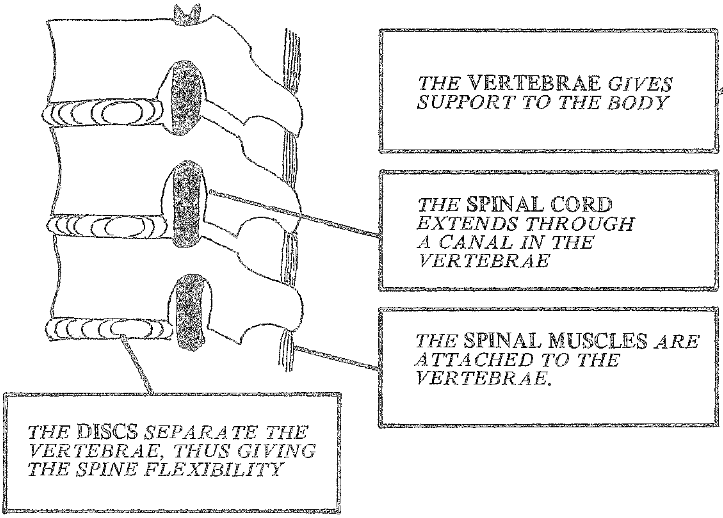


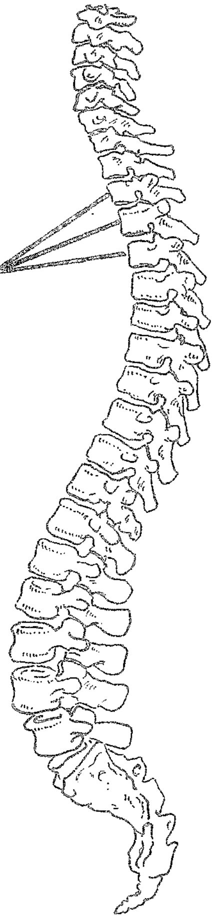
One in every four industrial injuries is caused by poor lifting, pushing or pulling techniques.
You can find out how to prevent back injuries by using good lifting techniques.
This is mainly a reading option.

Lifting and Handling

THE SPINE AND INJURIES TO THE BACK

Common injuries caused by bad lifting techniques include back injuries, hernias, foot and hand injuries.


THE VERTEBRAE GIVES SUPPORT TO THE BODY
THE SPINAL CORD EXTENDS THROUGH A CANAL IN THE VERTEBRAE
THE SPINAL MUSCLES ARE ATTACHED TO THE VERTEBRAE.
THE DISCS SEPARATE THE VERTEBRAE, THUS GIVING THE SPINE FLEXIBILITY



Although the vertebrae are bound together by ligaments, the muscles also help keep the spine rigid when necessary. Back injuries most frequently occur either when the load to be carried is excessively heavy or when the back is twisted or bent as the load is being lifted.

While growing up it is important to prevent any back injury which may affect the developing spine. Such injuries are less likely to occur if loads are lifted and carried correctly.

This extract was adapted from an article in the *Australian Safety News:*

> *When excessive force is applied to the ligaments of the spine, some of the fibres rupture, causing acute back pain, stiffness and spasm of the spinal muscles.*
>
> *Any tear in a ligament will heal leaving scar tissue. This tissue is weaker than the original ligament and becomes prone to injury.*
>
> *Repeated strain reduces the competence of the ligaments, the joints become lax, and there are other changes also. These changes can be seen on X-ray film. They cause bone to build up around the edges of the vertebrae.*
>
> *The casings of the discs are eventually disrupted and the disc sac is damaged. The disc substance dries up prematurely or ruptures, and X-ray shows that the disc space between the vertebrae narrows. Gradually the joints seize up, putting a greater load of work on to the remaining joints.*
>
> *Occasionally, the disc substance ruptures through a weak spot in the back of the casing, causing the nerve emerging behind it from the spinal cord to be compressed and irritated. This causes pain and some numbness and muscle weakness.*
>
> *The region that bears the brunt of most of the strain is the lower lumbar spine. The disc protrudes most frequently here at the origin of the sciatic nerve. For this reason, sciatica is frequently associated with disc trouble.*

(By courtesy Trade Union Clinic and Research Centre Hospital, Footscray, Victoria.)

could you use a hand, a hand a hand, a hand a hand, a hand?

THE LOAD

Before picking up a load, make sure you know where it is to go, otherwise you may be holding it for longer than necessary.

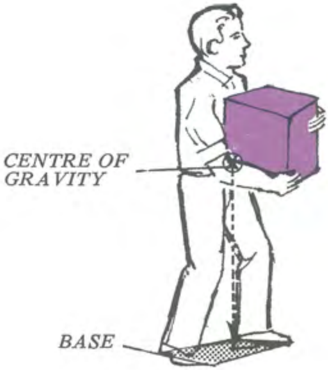
If the load is quite heavy or awkward it would be wise to ask somebody to help you.

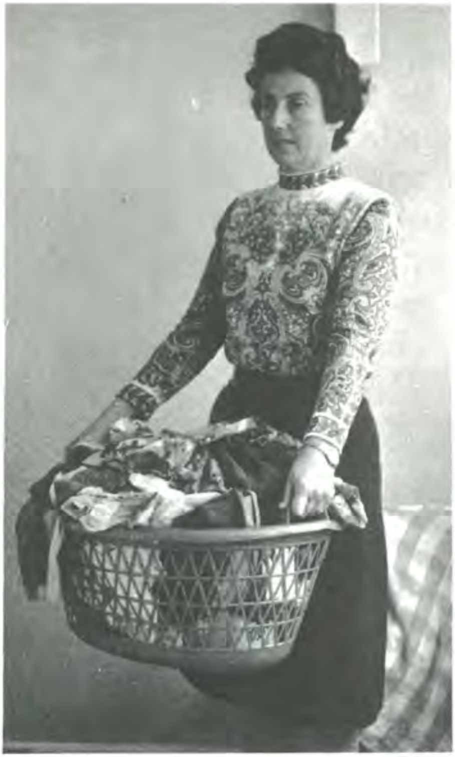
In the upper photo at right the way the baby is being carried is putting a strain on the mother's arms and back. The lower photo shows the baby being carried in a more comfortable position.

✍ 5.1 How has the mother helped relieve the strain on her back?

FOOT POSITION

When lifting loads make sure you are properly balanced. Your feet should be apart with one slightly ahead of the other. The line from your centre of gravity should be between your feet so that you don't topple over.

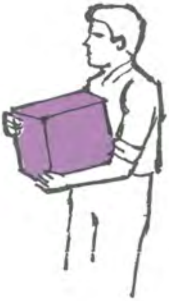




THE HOLD

Generally it is more comfortable to hold an object in the palms of the hands rather than with the fingertips. In carrying something like a clothes basket, as shown in the photo at left, the fingertip grip may be more comfortable.

If a box or carton is not too heavy it may be easier to hold by diagonally opposite corners as shown below.

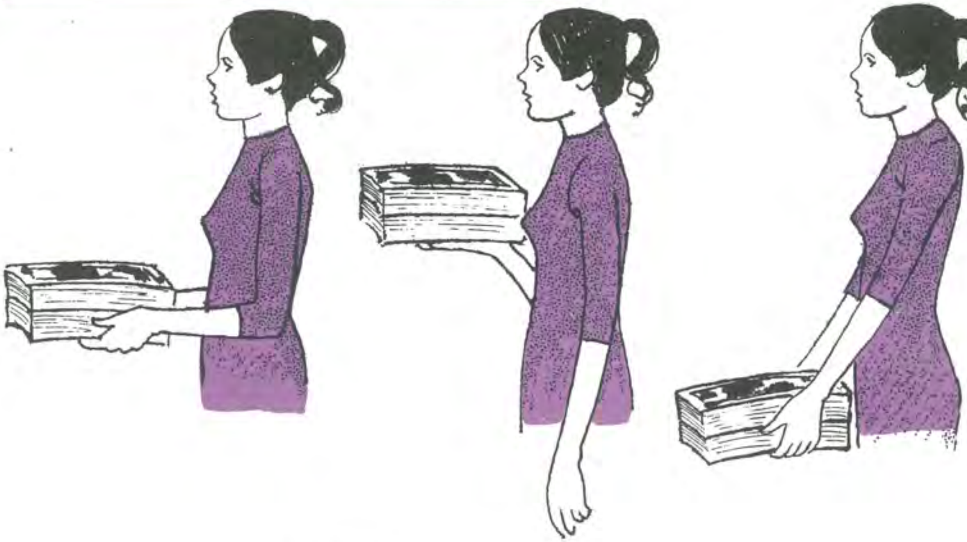


A STRAIGHT BACK

Muscles used to twist the spine can't, at the same time, be used to brace the vertebrae. If the back is not straight when objects are lifted the spinal ligaments are subjected to extra strain. Tucking the chin in toward the chest will help to keep the back straight.

Bending the knees to get down to a load can also help prevent spinal muscles being used for lifting. When the legs are straightened the more powerful leg muscles help lift the load while the spinal muscles still support the vertebrae.

ACTIVITY: POSITION OF THE ARMS

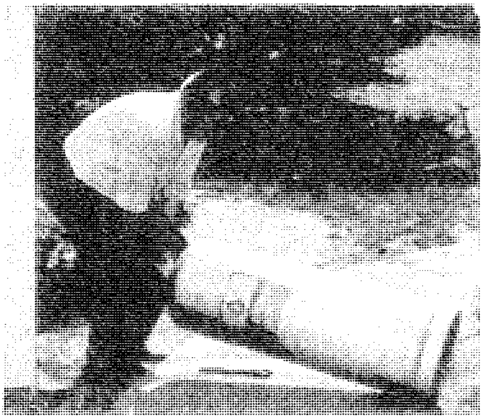


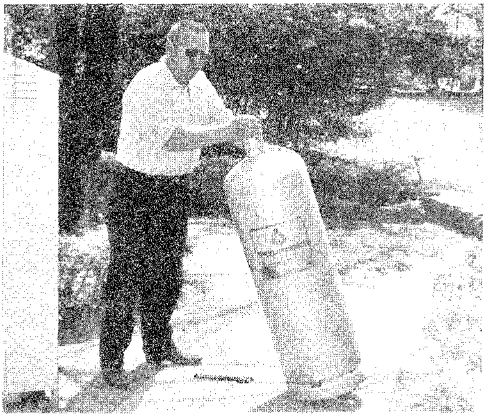
You will need:

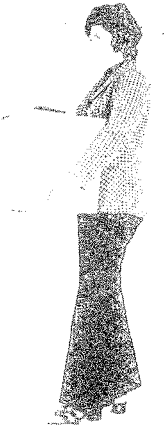
- 1 load, e.g. 2 telephone books.

In the illustrations above the load is being held in three different ways. Obtain a load similar to the one shown and try to hold it, for two minutes, in each of the three positions shown. Allow yourself a few minutes rest between each attempt.

5.2 Describe the elbow and arm position you would use if you had to hold a load for some time.





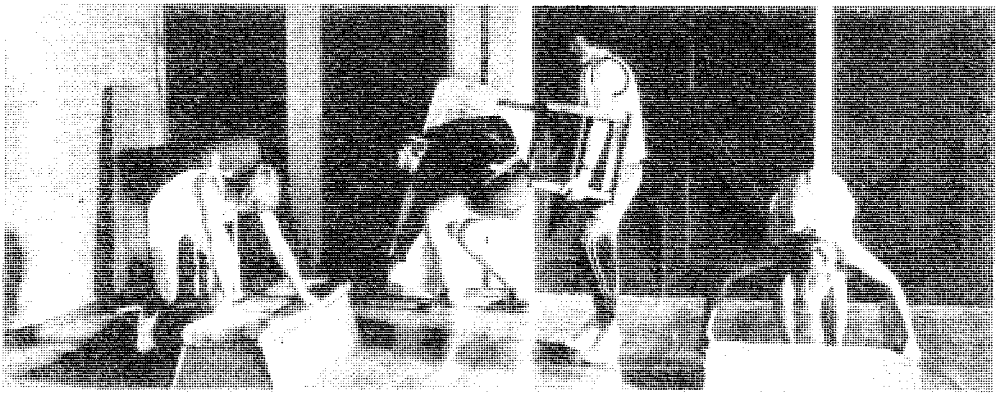


5.3 The man shown in the photos above is lifting the gas cylinder safely. He is doing at least two things to help him lift the cylinder without injury. What are they?

5.4 In what ways is the woman in the photo at left making her carrying task easier?

5.5 Look at the photo below of boys lifting and carrying different objects. For each boy note down any correct or incorrect techniques he is using.

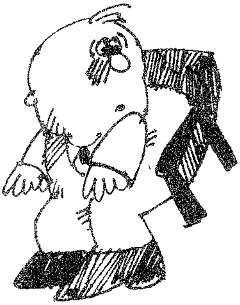
Try to use the hints given to develop good lifting and carrying habits of your own. Back injuries may occur even though the task looks easy. They may often be prevented with just a little forethought.



You can check your answers by turning to page 88 of this book.

OPTION

6

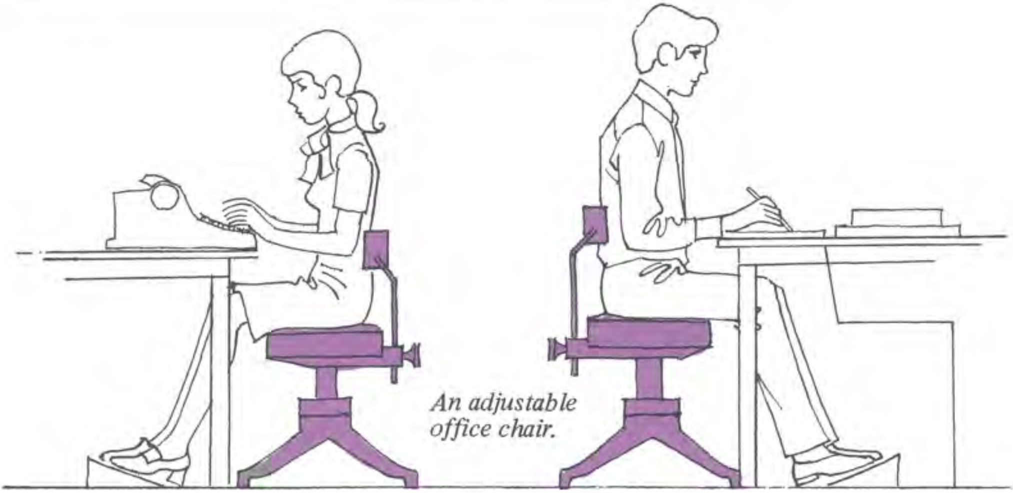


How suitable is the furniture and working space you use? This option involves you in looking at everyday items critically. Perhaps they could be made easier to use.

Design for Performance

Have you tried to sit on a kindergarten chair lately? Or ride a child's tricycle? These things are very uncomfortable for you because they're not designed for people your size. But even a chair of nearly the right size can cause trouble. Sitting in a badly designed seat can make you feel tired. It can also lead to back troubles. It can even affect your muscles, nervous and blood systems and change the shape of your spine. In Australia more and more people have back troubles. Badly designed seating may be one of the causes.

ACTIVITY 1: TO FIND THE IDEAL SEAT HEIGHT



An adjustable office chair.

You will need:

- 1 tape measure (or ruler).

Most people find that a comfortable seat height is equal to the distance from their heel to the back of their knee. This distance may be called the ideal seat height.

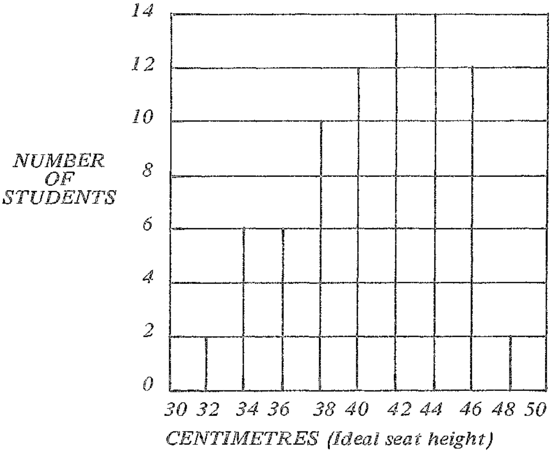
Measure the ideal seat height of a number of students. Also measure the height of a number of different seats used by these students. Include seats found at home as well as those used in different rooms at school.

6.1 Use the table on page 18 of your record book to record your results.

6.2 Why are all the seats in a classroom often the same height? From your measurements is it desirable that all seats be at the same height? Which students find school seats most comfortable?

6.3 If your measurements show that you are not working at your ideal seat height, suggest some things you could do to make your working position more comfortable.

DISCUSSION

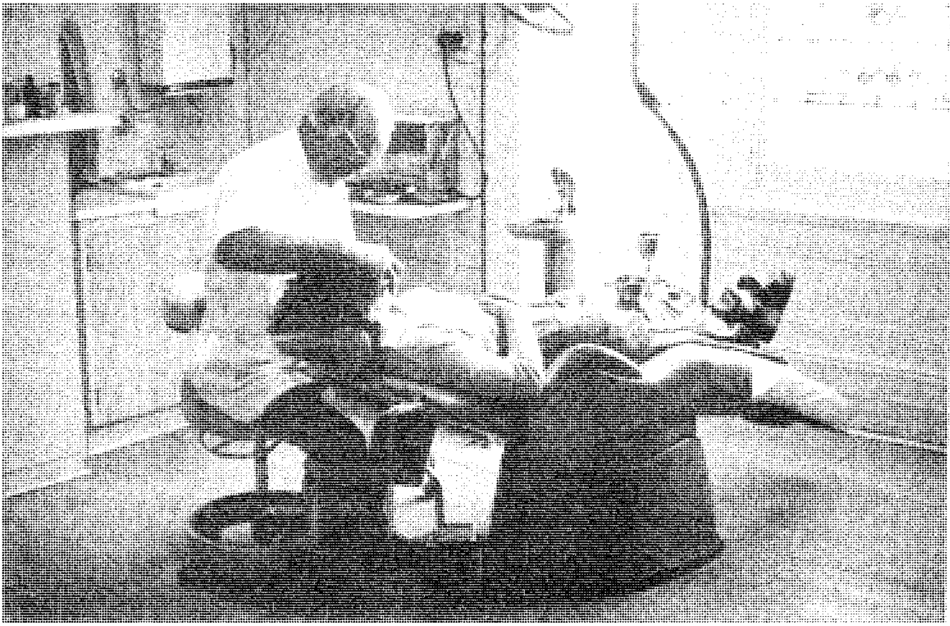


The graph shows the ideal seat heights of 58 students. What would be the most suitable seat height for this group? If you were a manufacturer of furniture, what could you do for the students whose ideal seat height is

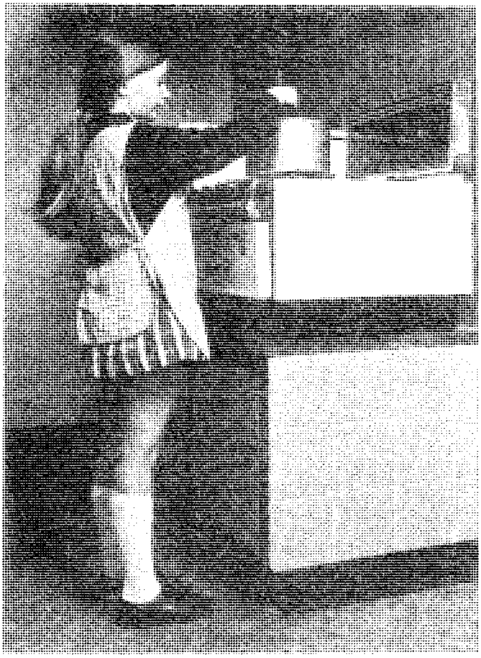
☐ 30 to 32 centimetres?
☐ 46 to 48 centimetres?

Adjustable chairs are used to bring a seated person to a convenient height. Either for the person seated in them, e.g. office chairs . . .

. . . or for the person working beside them e.g. dentists or hairdressers.



A dentist's adjustable chair.



WORKING HEIGHTS

The height of a bench or table may inconvenience a person who has to stand while working at it. It may even contribute to accidents. Science room benches, work benches, kitchen sinks, etc., may be at awkward heights for those using them. A dentist can alter his working height by adjusting the chair. What could the girl shown in the photo at left do to alter her working height?

CONTROLS AND DIALS

An organist must have his pedals, stops and keys within easy reach. Otherwise he is liable to play wrong notes during difficult passages, particularly if they are to be played quickly.

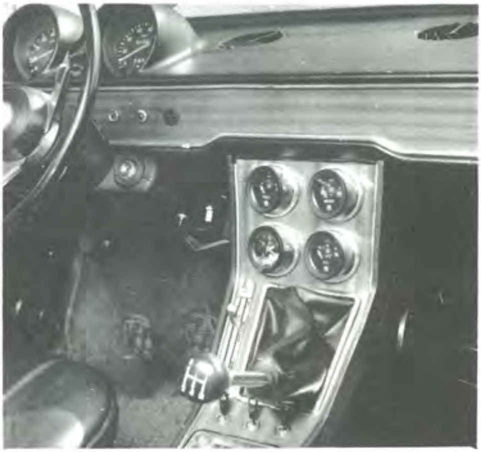
A car driver must not only know exactly where the brake pedal, horn and other controls are located—he must also be able to reach these controls quickly and easily.

There should also be some uniformity of placement of controls so that people can readily operate cars, television sets or stoves made by different manufacturers.

ACTIVITY 2: ARRANGEMENT OF CONTROLS AND DIALS

Sit in the driver's seat of a car. Try to reach all the knobs, switches and pedals while wearing a seat-belt. Can you read all the instruments easily? Can you reach the hand-brake and other controls to operate them efficiently? Can you improve your position by adjusting the seat? If not, what adjustments would have to be made to enable a person your size to reach the controls easily?

6.4 Complete the checklist in your record book. If possible, repeat this for a number of different makes and models of cars. Compare your checklist with others. What changes could be made to car controls to make them quicker to locate and easier to use?



Tilted dials help the car driver.

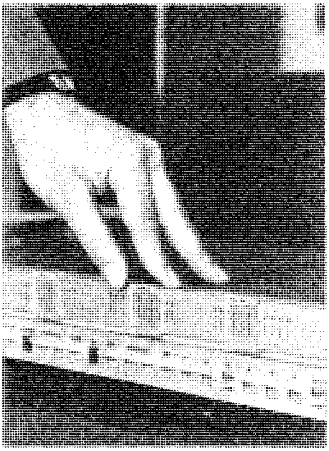
Instrument dials generally need to be at right-angles to the line of vision to be seen clearly. For people seated in a fixed position dials may be made easier to read by being tilted.

If there are a number of dials to be read they should all be the same distance from the eyes. There is then no need to refocus as you look from one dial to another.

Switches also should be grouped conveniently – neither too far apart (which results in unnecessary movement) nor close together (when you may operate the wrong switch accidentally).

Dials grouped for easy reading.

SWITCHING ON



A sliding control.

Some switches turn only on or off.

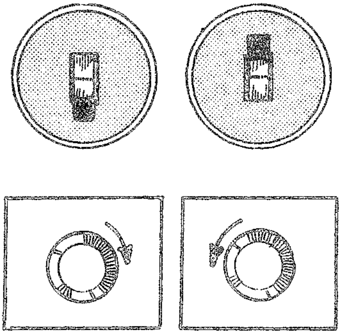
Some switches may have intermediate positions, e.g. the slow and fast positions for windscreen wipers on some cars.

There are other controls which may be adjusted more gradually such as taps, levers and the knobs on stoves.

Confusion may result in using switches if they do not operate in the way we expect.

6.5 Which way would you move a light switch to turn the light off? In which direction would you turn a radio knob to turn the radio off?

Standardization is important in preventing accidents and making things easier to use. The colour coding of traffic lights and electric wires and the grouping of letters on a typewriter keyboard are familiar examples. Look at street names and highway signs in your area. They should be large and clear and placed in such a way that drivers know where to look for them at intersections. Safety belts would be safer in an emergency if they all unbuckled in the same way. How many different ways are there of buckling and unbuckling safety belts?



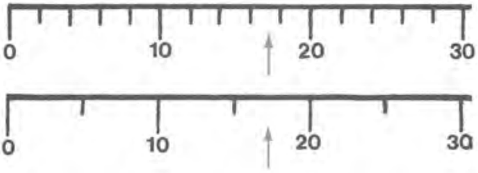
ACTIVITY 3: DIAL DESIGN

Items which are mass produced are sometimes poorly designed. This can be because cost consideration can result in controls and dials being poorly placed and difficult to read. In some other cases more consideration is given to their appearance than to their function.

Compare the dial design of a number of different transistor radios. Which do you find easiest to tune in correctly? You may feel that none of the dials you study are really suitable.

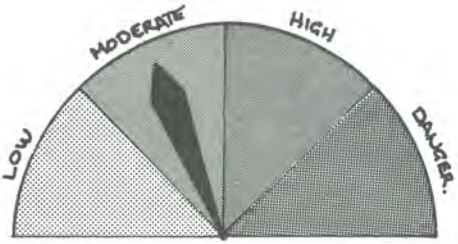
6.6 What features should a transistor dial have that will make tuning in both quick and easy?

6.7 Which of the scales at the left is easier to read at a glance? Try to explain why this is so.



Sometimes it is not important to have an exact reading.

There is sometimes a conflict between good looks and functional design. Good design combines both these qualities.

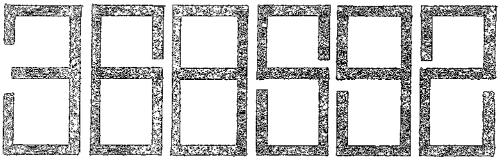


Fire risk indicator.

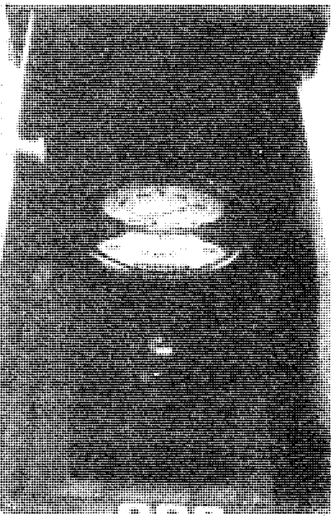
Activity 3 continued next page

6.8 Many dials are poorly designed or placed. Each example below has been chosen to illustrate a particular defect. Try to describe the defects and suggest improvements.

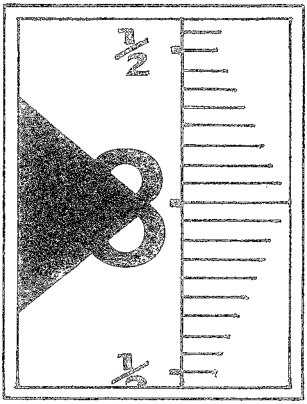
What is the number?



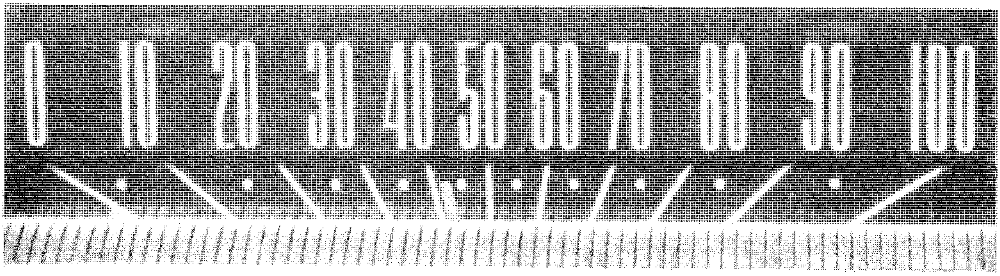
What is the dial reading?



What is the figure?



Quickly! How fast is the car travelling?



6.9 Look critically at the dials you see every day. They may be in a car, on a radio or some item of science room equipment. Select a dial which you feel is poorly designed. Draw it as it appears and list its short-comings beside the drawing.

Many everyday items are designed to suit an average person, e.g. cars, chairs, ready-made clothing. Most doorways allow even the tallest person to pass through and ceilings are usually high enough for people to stand upright. There are, however, some common items which do not, as often they could, take into account the differences between individuals. Examples include:

☐ size and height of school lockers and other storage spaces

☐ seat width and leg space in buses, aircraft, theatres, etc.

☐ position of power points and location of switches.

In many cases unnecessary problems and fatigue result from poor design of furniture, instruments and working spaces. With a little knowledge and forethought, many of these difficulties could be fairly readily prevented.

FURTHER ACTIVITY

A well designed item serves its main purpose adequately and is also pleasing to the eye. Select some object and write an evaluation of its design related to its performance. You could write about a household item, a car or caravan, or something found at school. Note down its good and bad points together with your evidence for these judgements. How would you improve the object you selected?

You can check your answers by turning to page 89 of this book.

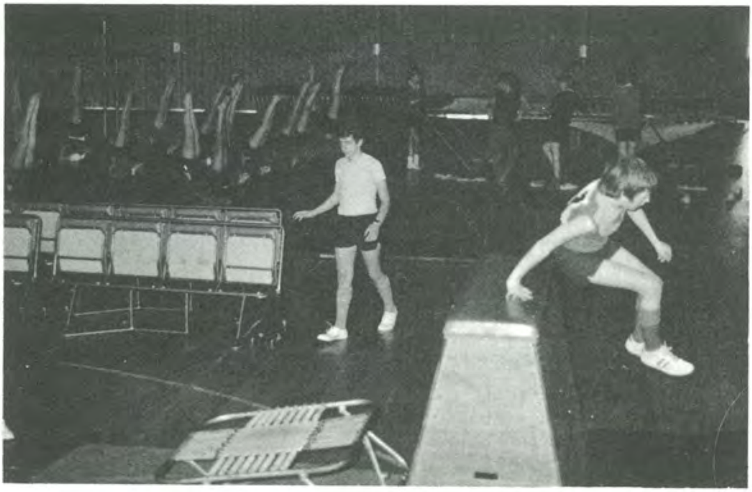
OPTION

7

In this option you can find out how exercise affects the blood system and the respiratory system. There is also some discussion on training methods.

Training

Exercises not only increase the strength of muscles, they also improve both heart and lung activity. However, exercise must be done for a sufficiently long period before beneficial changes are produced in the body. Quite marked effects on the blood and respiratory systems have been studied during the course of special training programs.



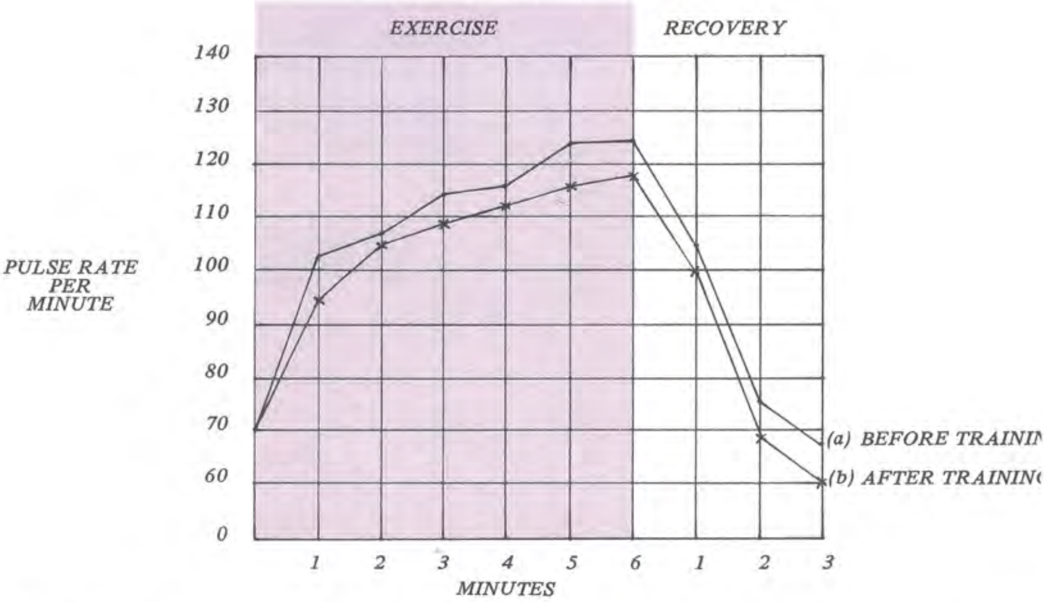
ACTIVITY 1: IMPROVING THE FLOW OF BLOOD

The graph below shows the effect of a light run on a man's pulse rate. He had done no training before run (a) but had trained for several weeks prior to run (b).

✍ 7.1 Compare the man's pulse rate before and after he had begun training. In your record book describe the effect exercise has had on his pulse rate.

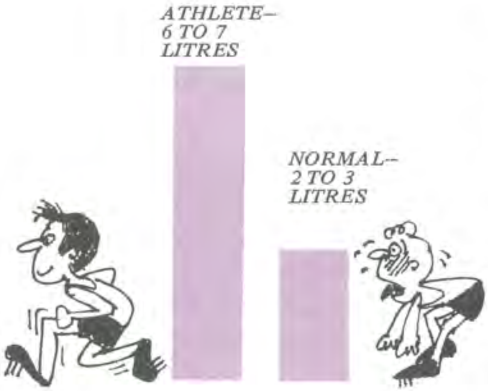
Training reduces the resting pulse rate (although this is not shown in the graph). In some cases it may decrease by 20 beats per minute. The pulse rate response to exercise varies between individuals. It may also vary a little for the same individual at different times.

Most information on changes in the blood and respiratory systems as a result of exercise has come from research involving men. This does not mean that women and girls do not benefit from training. Girls between 12 and 15 benefit most.



Effect of training upon the pulse rate of a runner.
(By courtesy of E.R. Sandstrom, Department of Physical Education, University of Melbourne.)

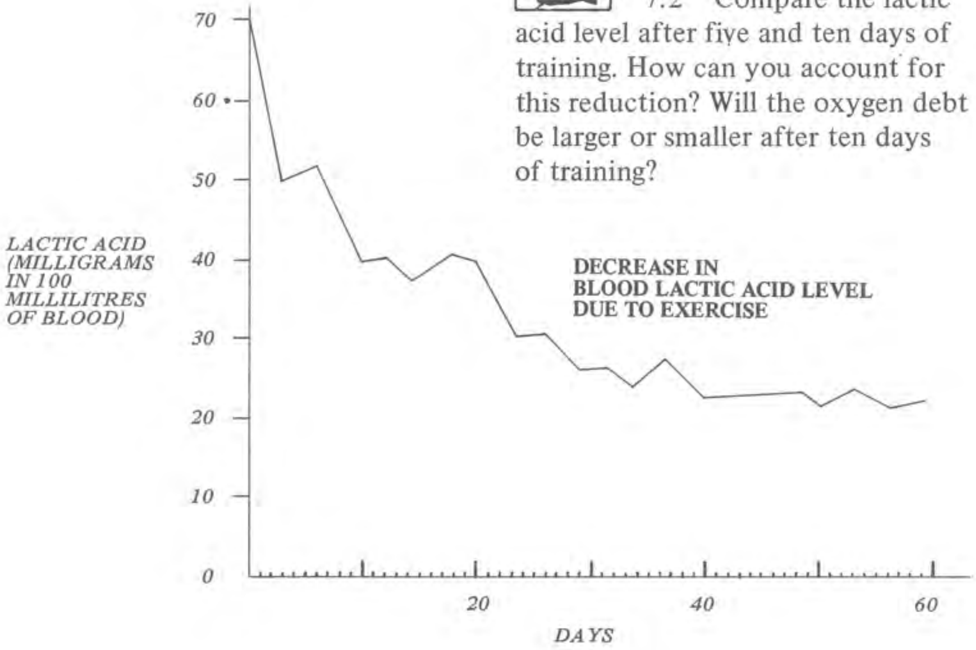
ACTIVITY 2: IMPROVING THE OXYGEN UPTAKE



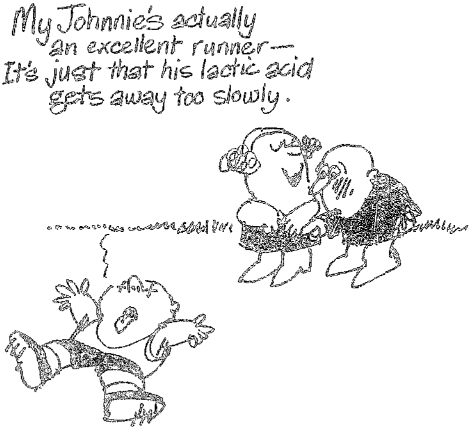
Most adult males, working at their hardest, may use up to 3 litres of oxygen per minute. Olympic athletes, however, may use 6 to 7 litres of oxygen per minute. The more oxygen made available to the muscles the greater the delay before the onset of fatigue.

Decreased oxygen supply results in an increase in lactic acid in active muscles. After a group of men had exercised by running on a treadmill, the lactic acid present in their blood was measured. They exercised for the same time each day but after 20 days they increased the speed at which they ran. Their results are shown on the graph below.

7.2 Compare the lactic acid level after five and ten days of training. How can you account for this reduction? Will the oxygen debt be larger or smaller after ten days of training?



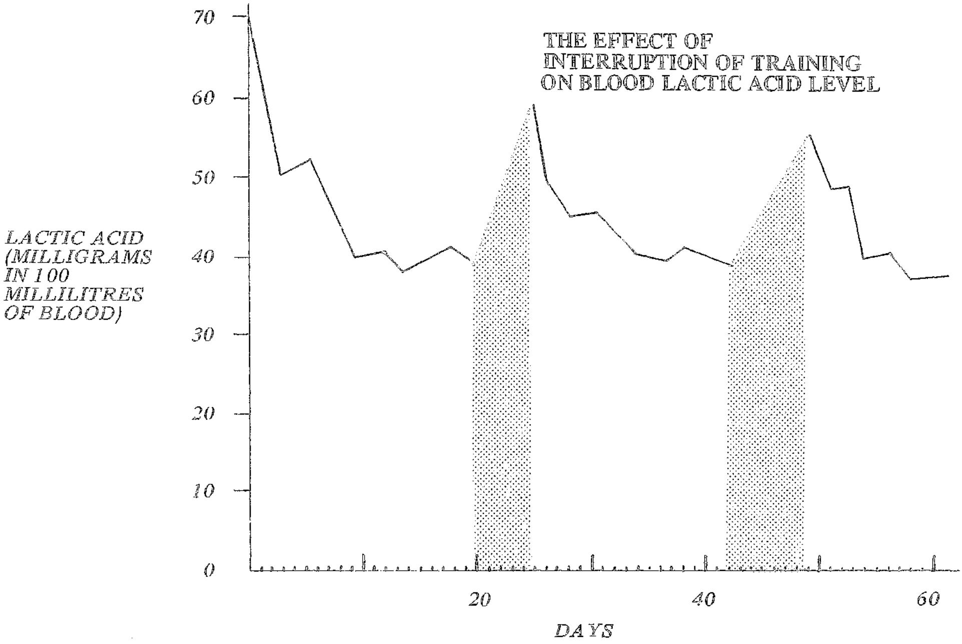
The graph below shows the effect on the level of lactic acid in the blood when training is interrupted for a period of time.


My Johnnie's actually an excellent runner— It's just that his lactic acid gets away too slowly.

7.3 For how many days was training interrupted each time? What effect did this non-training period have on the level of lactic acid in the blood? What changes in the respiratory and/or blood systems could have resulted in such a change?

Some people try to train just by 'sweating it out'. They keep working at a particular exercise until they become too tired to continue, often before the training has had any beneficial effect.

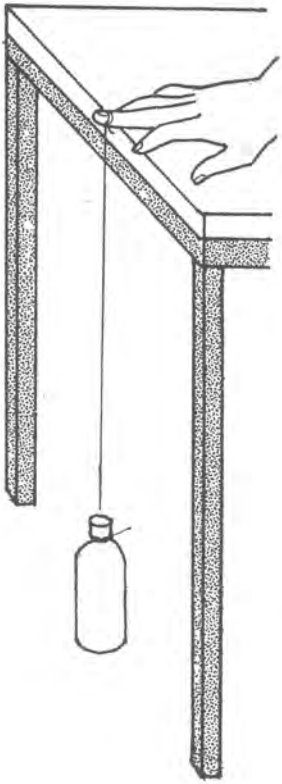
Your body is capable of doing a lot of work. However, it can't work hard for long without some rest. Just how does rest affect performance?


THE EFFECT OF INTERRUPTION OF TRAINING ON BLOOD LACTIC ACID LEVEL

ACTIVITY 3: WHO NEEDS A REST?

For this activity you should work with a partner.

You will need:
- 1 plastic bottle, e.g. a small detergent bottle
- 1 piece of string
- 1 watch (or clock) with a sweep second-hand.



Fill the bottle with water and screw the cap on tightly. Securely tie one end of the string around the neck of the bottle. Tie a noose in the other end of the string, large enough for your middle finger to fit through. Set up the apparatus as shown at left.

Position your hand at the edge of the table, with the bottle on the floor. When you raise your middle finger you will lift the bottle above the floor. The rest of your hand must stay flat.

For the first part of this activity you are to move the bottle up and down as quickly as possible. Keep doing this for five minutes. Your partner should count the number of times the bottle touches the floor.

While you rest your partner should repeat this activity.

7.4 Record both sets of results on the table in your record book.

The procedure for the second part of this activity is only slightly different. The apparatus is the same but you will be resting at times during the activity. As your partner will be looking at the watch to tell you exactly when to start and stop, you will have to count the number of times the bottle touches the floor.

You are to carry out the activity for 25 seconds exactly, then rest for 5 seconds exactly. A slight complication comes in here. You will actually be working only 50 seconds in every minute. To get 5 minutes work done you will need to be timed for 6 minutes.

Change places with your partner and repeat this part of the activity.

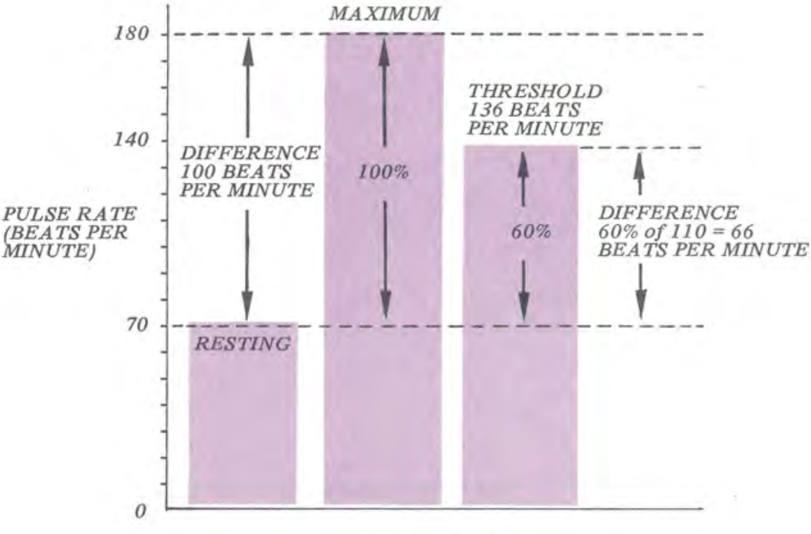
7.5 Record both sets of results. What differences are there in your results in each case? Try to explain the differences you observe. Is there as great a difference in your partner's results?

A treadmill.

In the United States, in 1959, the physiologist M.J. Karvonen investigated endurance training by observing people exercising on a treadmill. Endurance training is designed to delay the build up of an oxygen debt. From his observations Karvonen concluded that exercise could improve the performance of the heart.

Such improvement is best achieved when exercising at what he called the threshold rate. This rate is 60 per cent of the way between the resting pulse rate and the maximum pulse rate.

For example, if the maximum pulse rate is 180 beats per minute and the resting pulse rate is 70 beats per minute, then the difference is 110. Sixty per cent of 110 is 66. Thus the threshold rate would be 136 beats per minute.



ACTIVITY 4: ESTIMATION OF THRESHOLD RATE

You can try to work out your own threshold rate. However, in practice, it is very difficult to find the maximum pulse rate.

Measure your resting pulse rate. (See page 44.) Repeat this measurement.

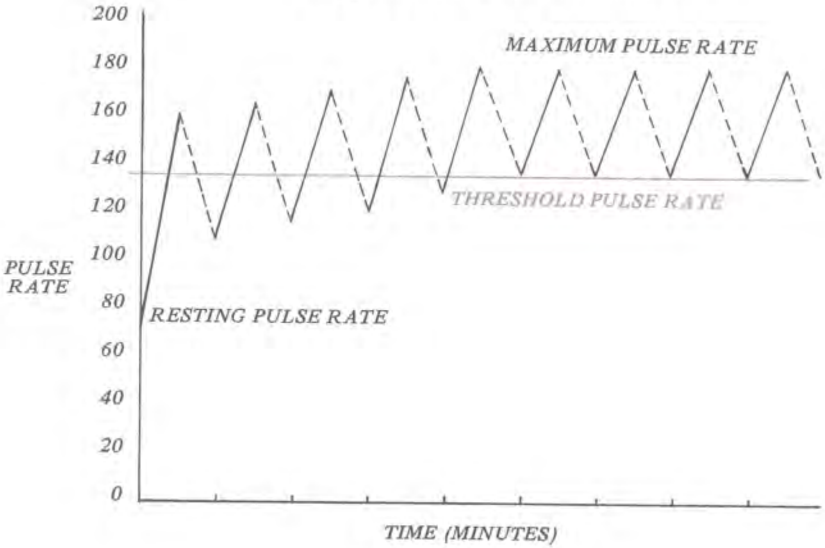
✍ 7.6 Record your results and find the average.

Next, sprint 100 metres as fast as you can. Take your pulse for the first minute after you finish running. This figure will be used as your maximum pulse rate.

✍ 7.7 Record your results. Try to calculate your own threshold rate.

INTERVAL TRAINING

Interval training consists of bursts of activity with recovery periods in between. Effective training is achieved with alternating periods of 30 seconds of exercise and 30 seconds of rest. At the end of the exercise period the heart rate may be up to the maximum. During the rest period it drops to about the threshold rate.



Other types of endurance training can be used to improve heart and lung performance. These include:

- jogging (for general fitness)
- circuit training (a set of exercises done in sequence and repeated a number of times in a given time)
- activity running (for middle- and long-distance runners—alternating sprints with slow running).

You may well consider beginning one of these training programs. Moderate regular exercise benefits health—whether you are young or old.

If you wish to find out more about a particular type of training some of the following books may be useful.

Bowerman, W.J. and Harris, W.E. *Jogging.* New York, Grosset and Dunlap, 1967.
Cooper, K.H. *The New Aerobics.* New York, Bantam, 1970.
Morgan, R.M. and Adamson, G.T. *Circuit Training.* London, Bell, 1957.
Willee, A.W. *Dynamic Football.* Melbourne, Lansdowne, 1967.

You can check your answers by turning to page 90 of this book.

Check Your Answers

Check your answers with the answers given here. If you cannot agree with a given answer, discuss it with another student, or go back to the particular section of work and read that section again.

If you are still in doubt, ask a teacher.

MAN—THE VERSATILE ANIMAL

1 The whole body can move forward, backward, sideward, upward and downward. It can rotate, as in a forward or backward somersault. You could also have mentioned that the body can rotate on its own axis, as in a pirouette.

2 The joints you observed may be grouped as follows:

Hinge e.g. elbow, knee, toe, knuckle.

Ball and socket e.g. shoulder, hip.

3 When the arm is bent the biceps muscle contracts and the triceps muscle relaxes.

4 When the arm is straightened the triceps muscle contracts and the biceps muscle relaxes.

8 Pedalling involves the use of muscles, which need oxygen for the release of energy. The greater the speed of pedalling, the more oxygen is absorbed.

9 The oxygen absorbed at 13 kilometres per hour is 3.2 litres per minute.

10 At 10 kilometres per hour 2.5 litres of oxygen are absorbed per minute. For each litre of oxygen absorbed, enough food is oxidized to release 19.2 kilojoules of energy.

$2.5 \times 19.2 = 48$

Pedalling at 10 kilometres per hour requires the release of 48 kilojoules per minute.

11

ACTIVITY	TIME (MINUTES)	ENERGY USED (kJ/MINUTE)	CALCULATIONS	TOTAL ENERGY (kJ)
SITTING (homework)	30	4.8	30 x 4.8	144.0
GARDENING (light work)	15	20.7	15 x 20.7	310.5
BRISK WALK UPHILL	4	43.2	4 x 43.2	172.8
STANDING	30	6.0	30 x 6.0	180.0
SQUASH	60	58.6	60 x 58.6	3516.0
				4323.3

Lyndal would have used about 4300 kilojoules.

12 ☐ If the energy taken in as food is greater than the energy used, some may be stored as glycogen in the liver. Most, however, will be stored as fat beneath the skin and around certain internal organs. This would result in an increase in weight of the person concerned.

☐ If the energy taken in as food is less than the energy used, then the additional energy required would be provided from food stored within the body. As the food stores are used, there would be a decrease in body weight. Cutting down the amount of food taken in may be one means of slimming, but anyone who intends to diet strictly should only do so in consultation with a doctor.

TEST YOURSELF–MAN, THE VERSATILE ANIMAL

1 **B**

In A, C and D the man is more active than in B. These activities would require more oxygen being used than in B.

2 **C** Sprinting requires more oxygen than the man can obtain during the sprint so he would have an oxygen debt after one minute.

In B the man is resting and in A and D he is only doing mild exercise.

3 **C** A sprinter would develop an oxygen debt and the lactic acid concentration in his muscles would therefore increase.

The man in A, B and D is unlikely to have an oxygen debt.

4 **C, D**

In A and B the joint can only be moved in one direction. A ball and socket joint allows movement to take place in a number of different directions. This freedom of movement is found in both the shoulder and hip joints.

Test Yourself Answers continued next page

5 Upper thigh muscle

The shin and calf muscles would cause the foot alone to move. The contraction of the lower thigh muscle would cause the leg to bend even more. The upper thigh muscle is the only muscle which, on contracting, would cause the leg to straighten.

6 B The region marked X is the knee joint; it permits the leg to bend at the knee.

7 Ligaments

Hold bones together at the joints.

8 Tendons

Join muscle to bone.

9 D When a muscle contracts, one group of filaments moves in between the other group of filaments. The more the filaments move in, the greater the contraction of the muscle. The filaments do not change in shape.

10 B The shin muscle contracts to pull the foot up. At the same time the calf muscle relaxes and is lengthened.

11 A

B is only partly correct because, although some is used for movement, most of the energy made available by tissue respiration is converted to heat.

C is incorrect because tissue respiration takes place in the cells.

D is only partly correct because the energy made available by tissue respiration is used to produce many substances other than those which cause muscles to contract.

12 D About 20 litres of air are breathed for every litre of oxygen absorbed. Therefore he would absorb 5 litres of oxygen from 100 litres of air.

13 About 23 kJ

There are at least two ways of calculating the answer:

☐ 12 litres of oxygen would release (12 × 19.2) kJ in 10 minutes, i.e. 230.4 kJ. The man would therefore release 23.04 kJ in 1 minute.

☐ In 1 minute the man would absorb (12 ÷ 10) litres of oxygen. 1.2 litres of oxygen would release (1.2 × 19.2) kJ, i.e. 23.04 kJ. The man would therefore release 23.04 kJ in 1 minute.

OPTION 1: MUSCULAR STRENGTH

1.1 Possible reasons for differences in static strength measurements include

☐ size of the muscles

☐ sex

☐ age

☐ general fitness.

There is a considerable difference usually between individual measurements of static strength. It is also true that on different occasions for a particular individual there will be different measurements of strength.

1.3 Probably your static strength seems quite low. Generally, people with greater static strength also have greater dynamic strength. They may have more active muscle fibres and consequently larger muscles. Their muscles probably operate more efficiently.

1.5 Generally, those people who perform well in dynamic strength tests have well developed, efficient muscle systems.

OPTION 2: ACQUIRING SKILL

2.2 You probably noticed an improvement in the performance of the skill over a period of time. The amount of improvement will depend on the performer, his previous skills, and the skill being acquired. You probably learned the skill more quickly when you began. You could have been more enthusiastic then. The more quickly you master the skill, the more difficult it is to improve even further.

2.4 With the blindfold on, you could not see the light and it was difficult to learn the skill.
The knowledge of results (being able to see when you were about to make an error) made it easier to learn the skill.

2.5 When repeating the activity more quickly, more mistakes are made.

2.7 If more decisions are to be made (i.e. the number of card types to choose from), then more wrong decisions are likely to be made.
When you try to make decisions more quickly you increase the likelihood of making wrong ones.

OPTION 3: THE CEASELESS PUMP

3.4 You probably noticed that the resting pulse rate of most people was different.

3.5 Again, you probably noticed that the pulse rate of most people after exercise was different, but in all cases, it was higher than the resting pulse rate. The increase in the pulse rate of most people is different. The increase depends on how much exercise people normally do.

3.6 When the heart beats faster, blood circulates faster. More blood reaches the muscles in a given time and this means that more oxygen molecules are available for oxidation of molecules from foods. This provides more energy. Oxygen oxidizes food and, through a chain of reactions, energy is released. Faster heartbeats ensure that more energy is available for the muscles during exercise.

3.8 After a few minutes your left arm probably felt tired and you began to feel slight discomfort and pain. Shortly afterward the pain probably increased and further clasping of the hand was impossible. Once all the food molecules in the cells have been oxidized, there is very little in the cells which can be used for energy. Since the blood vessels are blocked, more food molecules cannot be supplied to the cells, nor can the wastes be removed. The pain was probably caused by this build-up of lactic acid in the cells.

In the right arm, normal tissue respiration could occur as the blood vessels were not blocked. There were no unusual sensations in this arm.

OPTION 4: THE MECHANICS OF JUMPING

4.1 ☐ After leaving the ground, the jumper's legs hang down below the hips. Some jumpers continue to 'pedal' their legs after leaving the ground.

☐ Just before landing the arms are pushed backward and the legs are thrust ahead of the hips.

☐ On landing the arms move forward and are then deliberately flung backward; the legs bend to lessen the shock of landing and then, as the body continues to move on, the legs straighten.

4.2 ☐ During a jump the centre of gravity follows a curved path (a parabola).

☐ The jumper leaves the ground at an angle of about 20° to the horizontal.

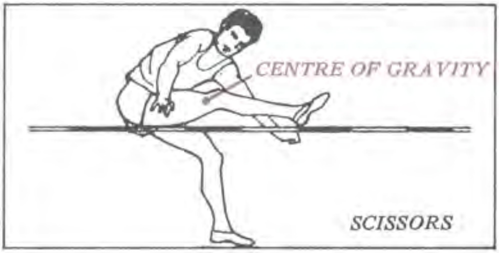
4.3 When the jet of water is projected at an angle of about 45° the greatest horizontal distance is covered. Thus, a long jumper would cover a greater distance if he could take-off at an angle of 45°. His actual angle of take-off is about 20° to the horizontal. This is because the body is moving forward prior to take-off and the jumper cannot leap upward hard enough. To achieve even the 20° angle the last stride of the run-up has to be shortened.

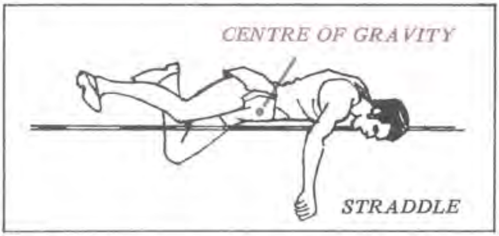
4.4 If the feet are thrust too far forward in landing then the centre of gravity will be behind the base. This would cause the jumper to fall backward.

4.5 A high jumper leaves the ground at an angle of about 80° to the horizontal. (He can't jump straight up in the air as he has to cover a small horizontal distance to get to the other side of the bar.)
The jumper's centre of gravity follows a very steep, curved path (a parabola).

4.6 A take-off angle as close as possible to 90° but still sufficient to allow a little horizontal movement.

4.7





Least energy is used for the straddle because the centre of gravity has to be moved a shorter vertical distance. In effect, the jumper doesn't have to jump as high to clear the bar.

4.8 Walking involves the placement of all your weight on one foot while the other is swung forward. You then transfer your weight from one foot to another–i.e. you 'fall' on to the forward foot. The reason you 'fall' forward is because your centre of gravity is moved ahead of your base (the foot which is taking the weight).

OPTION 5: LIFTING AND HANDLING

5.1 Ways in which the mother has helped relieve the strain on her back include:

- ☐ allowing the baby's weight to be supported by her hip and legs rather than by the spine
- ☐ holding her back straight.

5.2 If you were required to hold a load for a long time it would be easier if you kept both arms straight with the elbows in to the sides of the body.

5.3 Good lifting techniques being used by the man include:

- ☐ back straight, chin tucked in
- ☐ two arms being used
- ☐ elbows in to the sides
- ☐ feet properly positioned, centre of gravity between feet
- ☐ knees bent prior to lifting the load.

5.4 Arms straight, elbows in to the sides of the body.

5.5 You could mention:

From the left	CORRECT TECHNIQUES	INCORRECT TECHNIQUES
FIRST BOY	Arms straight, elbows in, knees bent.	Back bent. An awkward load, have someone help.
SECOND BOY	Back straight, knees bent.	An awkward load, have someone help. Feet poorly positioned.
THIRD BOY	Arms straight, elbows in, back straight, chin in.	
FOURTH BOY		Back bent, arms bent. An awkward load, have someone help. Feet poorly positioned.

6.2 Most school equipment is mass produced and often made to standard plans and sizes. As any class or group of people have different body dimensions it is probably not a good idea to have all the seats the same height.
Those students whose ideal seat height is the same as the height of the school seats would find them most comfortable.

6.3 You could mention anything which could make your ideal seat height and the height of your chair correspond. e.g.

☐ use of a footrest

☐ use of a cushion

☐ use blocks to raise the table or chair

☐ use an adjustable chair.

6.4 Your results will depend on the make and model of the cars you examined. One obvious feature which would enable car controls to be quickly located would be to have some consistency of placement, e.g. the horn could be put in the same place in all cars.

6.5 In Australia you normally move a light switch up to turn it off. (In the USA moving the switch up turns the switch on!) When a radio knob is turned anti-clockwise the radio is turned off.

6.6 Possible features might include:

☐ an uncluttered, easy-to-read dial

☐ a pointer, or other marker, to show the exact position of the dial

☐ absence of slack in the dial so that it moves freely but positively.

6.7 Many people find the lower scale easier to read at a glance. The eye can divide up the spaces quickly and accurately and it is better to divide by eye than to have to count up the graduation marks.

6.8 ☐ The number is 368592. The point is that numerals should be clear and be able to be read quickly.

☐ It is hard to read the dial because it is at an angle to the direct line of vision.

☐ The figure could be 3 or 8. Numerals should be placed so they are not obscured by the pointer.

☐ The car's speed is about 42 km/h. The surroundings of the dial distract your eye; the pointer is too thick in relation to the scale divisions.

OPTION 7: TRAINING

7.1 Exercise has resulted in the person having a lower pulse rate both during and after a training run.
The trained heart reaches a lower maximum pulse rate during exercise. Possible reasons for this are:

☐ each beat of the heart circulates more blood in the body

☐ the body uses the oxygen available more efficiently.

Although training normally reduces the maximum pulse rate, the amount of reduction varies from individual to individual.

7.2 There is less lactic acid in the blood after 10 days of training than after 5. Training has increased the efficiency of operation of the muscles so that the same amount of exercise requires proportionately less oxygen. This results in less lactic acid being produced. After vigorous exercise there will be a smaller oxygen debt after 10 days of training.

7.3 The men stopped training for 5 days the first time and for 7 days the second time. In both cases, a non-training period resulted in an increase in the lactic acid level of the blood. This could have been due to factors such as:

☐ less efficient functioning of the blood and/or respiratory systems

☐ less efficient use of oxygen by the muscles.

7.5 During the rest periods muscle cells replenish their supplies of food molecules and oxygen and get rid of wastes like lactic acid. In cells that are working all the time the supplies are being used at a faster rate and the large amounts of lactic acid, which can't be removed fast enough, may cause pain and fatigue.

Many people were involved in the development and production of ASEP units.

As well as the ideas and suggestions contributed by ASEP staff members, valuable help was given by consultants, students and teachers throughout Australia during trials.

Members of the ASEP team associated with this unit included:

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